# Unlocking and securing Ecological Infrastructure (EI) investments: A review of EI investment models

by

Malukhanye Steven Mbopha



*Thesis presented in partial fulfilment of the requirements for the degree of Master of Science in Conservation Ecology at the Stellenbosch University*

Supervisor: Prof. Karen J. Esler

Co-supervisors: Dr Christo Marais and Prof. Theo E. Kleynhans

December 2019

## Declaration

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the authorship owner thereof (unless to the extent explicitly otherwise stated) and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

Date: .....

## Abstract

Ecological Infrastructure (EI) refers to a suite of natural or semi-natural functioning ecosystems that deliver a range of essential services to humankind. Examples of EI are coastal dunes, catchments, wetlands, plant communities (fynbos), and riparian corridors. The Ecosystem Services (ES) supplied by EI are increasingly recognised as key to South Africa's sustainable development future. The term 'Ecological infrastructure' emerged as a metaphor to communicate the significance and the role of natural ecosystems in supplying a variety of valuable goods and services to people. Ecological Infrastructure is equally as important as built-infrastructure (for example, roads, dams, buildings) although built infrastructure tends to receive a significantly greater budget allocation for maintenance, unlike EI, which is assumed to be self-sustainable. If EI is underinvested, rapid degradation and threats such as unsustainable veld fire regimes, droughts, climate change, and invasive alien plants will persist in dominating the ecological landscape. The South African government established Natural Resources Management (NRM) programmes to encourage protection, maintenance and restoration of EI. However, the realisation that funding currently dedicated to the maintenance and restoration of EI nationwide is inadequate has led to the need to scale-up and unlock further public and private sector investments to augment ecosystem-based management interventions.

The aim of this study was to improve the understanding of 'Unlocking and Securing Ecological Infrastructure investments' through a review of international experiences and similar models to NRM. The Systematic Literature Reviews (SLR) were conducted at a global scale to provide evidence-based policy advice, and were informed by both peer-reviewed and grey literature. The following objectives were achieved: (1) a review of the developmental needs and drivers behind decisions to invest in Ecological Infrastructure, as well as willingness of private landowners to participate and contribute to Ecological Infrastructure protection and conservation; (2) a review of policy context and institutional support mechanisms used to stimulate collaboration and cooperation between government and private landowners towards Ecological Infrastructure investment; (3) a review of successes, challenges, and failures of implementation of Payments for Ecosystems Services (PES) as a conservation mechanism and; (4) drawing lessons and insights from reported cases of government and private landowner cooperation for South African Ecological Infrastructure investment policy advice.

Results suggested that the need to invest is driven by the degradation of Ecological Infrastructure and the urgency to meet environmental and sustainable developmental goals. The willingness of landowners to invest and to participate is stimulated by the use of economic-based policies and compensatory mechanisms. Multi-sector collaborations, commonly known as Public-

Private Partnerships (PPP), through public policy support mechanisms (compensation and incentives programmes) were found to be essential institutional arrangements used to protect EI. The review of Agri-Environment Scheme investment models showed that cooperation between the public sector and private landowners through public policy results in better conservation management, particularly when ecological desires and outcomes are prioritised through monitoring and evaluation post conservation interventions. The review of PES revealed strong institutional, social, ecological and least economic/financial successes achieved in the implementation. However, challenges and failures were also experienced in different countries. In general, inclusive stakeholder engagement in PES design and implementation, coupled with effective monitoring and evaluation, results in better socio-economic and ecological delivery. While PES has a better potential to generate funding for Ecosystem Services delivery, it cannot be regarded as a replacement of traditional funding mechanisms.

The study contributes to the EI investment research agenda by recommending coordinated efforts to encourage EI investment from both public and private partners. This study further improves understanding of PES design, implementation, and monitoring and evaluation in order to inform policy and provide insights required to improve EI investment mechanisms. Recommendations provided will help to secure financial resources, mobilise investments and reform policies. Key lessons learnt will also provide evidence-based advice for policy development and decision-making processes which seek to protect natural ecosystems for present and future generations through Ecological Infrastructure investments.

**Keywords:** Ecological Infrastructure investments, funding mechanisms, partnerships, Payments for Ecosystems Services, economic-based policies, Natural Resources Management, policy advice

## Opsomming

Ekologiese Infrastruktuur (EI) is 'n natuurlike of semi-natuurlike ekosisteem wat 'n verskeidenheid van noodsaaklike dienste aan die mens bied, soos bergopvangs, vleilande, kusduine, fynbos en oewer-streek. Die ekosisteemdienste wat deur EI verskaf word, word toenemend beskou as essensieel vir Suid-Afrika se toekomstige volhoubare ontwikkeling. Die term 'ekologiese infrastruktuur' het na vore getree as 'n metafoor vir die betekenis en die waardevolle rol van natuurlike ekosisteme wat 'n verskeidenheid waardevolle goedere en dienste aan mense verskaf. Ekologiese infrastruktuur is ewe belangrik as geboude infrastruktuur (byvoorbeeld paaie, damme, geboue), hoewel geboude infrastruktuur geneig is om 'n aansienlik groter begrotingstoewysing vir opknapping te ontvang, in teenstelling met EI, wat as selfherstelbaar aanvaar word. As ekologiese infrastruktuur swak gefinansier word, bly dit agteruitgaan en bedreigings soos onvolhoubare veldbrandregimes, droogtes, klimaatverandering en indringerplante sal voortgaan om die ekologiese landskap te oorheers. Die Suid Afrikaanse regering het Natuurlike Hulpbronbestuur programme ingestel om die beskerming en herstel van EI, biodiversiteit en natuurlike hulpbronne aan te moedig. Onvoldoende befondsing vir die instandhouding en herstel van ekologiese infrastruktuur landwyd, het egter gelei tot die behoefte om beleggings deur die openbare en privaat sektor te vergroot en te ontsluit om ekosisteemgebaseerde bestuursintervensies uit te brei.

Die doel van hierdie studie was om die begrip van 'Ontsluiting en Beveiliging van Ekologiese Infrastruktuur-beleggings' te verbeter deur ‘n oorsig van internasionale ervarings en soortgelyke modelle vanNatuurlike Hulpbronbestuur. ‘n Internasionale Sistematiese Literatuuroorsig van eweknie ge-evalueerde literatuur en grys literatuur is uitgevoer in die soeke na bewese beleidadvies. Die volgende doelwitte is bereik: (1) ‘n oorsig van die ontwikkelingsbehoeftes en drywers van besluite om te belê in ekologiese infrastruktuur, asook bereidwilligheid van private grondeienaars om by te dra tot die beskerming en herstelling van die ekologiese infrastruktuur, (2) ‘oorsig van beleidagtergrond en institusionele ondersteuningsmeganismes wat gebruik word om samewerking tussen regerings- en privaat grondeienaars te stimuleer vir die belegging van ekologiese infrastruktuur, (3) ‘n oorsig van suksesse, uitdagings en mislukkings van implementering van Betalings vir Ekosisteemdienste as 'n bewaringsmeganisme, en (4) om insig te kry oor samewerking tussen die aangemelde gevalle van die regering en private grondeienaarsamewerking ten opsigte van beleggingsbeleid in Suid-Afrikaanse ekologiese infrastruktuur.

Die literatuuroorsig toon dat die behoefte om te belê gedryf word deur die agteruitgang van ekologiese infrastruktuur en die dringendheid om omgewings- en volhoubare ontwikkelingsdoelwitte te bereik. Die bereidwilligheid om te belê en deel te neem, word gestimuleer deur die gebruik van ekonomiese beleid en kompenserende meganismes. Multisektorale samewerking wat algemeen bekend staan as Publieke-Private Vennootskappe deur openbare beleidondersteuning meganismes, is noodsaaklik om institusionele reëlings te tref om ekologiese infrastruktuur te beskerm. Die literatuuroorsig van die Agri-Omgewingskemas se beleggingsmodele het getoon dat samewerking tussen openbare en private grondeienaars deur openbare beleid tot beter bewaringsbestuur lei, veral wanneer ekologiese begeertes prioriteit gegee word deur monitering en evaluering. Betalings vir Ekosisteemdienste resultate het verskeie institusionele, sosiale, ekonomiese/finansiële en ekologiese suksesse behaal. Uitdagings en mislukkings is ook ondervind in verskillende geografiese gebiede. Oor die algemeen, inklusiewe belanghebber betrokkenheid by Betalings vir Ekosisteemdienste-ontwerp en, implementering, tesame met effektiewe monitering en evaluering, lei tot beter sosio-ekonomiese en ekologiese lewering. Betalings vir Ekosisteemdienste het 'n beter potensiaal om befondsing vir die lewering van ekosisteemdienste te genereer, hoewel dit nie as 'n vervanging van tradisionele befondsingsmeganismes beskou kan word nie.

Die studie dra by tot die EI-beleggingsnavorsingsagenda deur gekoördineerde pogings aan te beveel om EI-belegging van beide openbare en private vennote aan te moedig. Hierdie studie verbeter ook die begrip van PES se ontwerp, implementering, asook die monitering en evalueringsdinamika om die beleid in te lig en nodige insigte te lewer om beleggingsmeganismes vir ekologiese infrastruktuur te adviseer. Die studie aanbevelings sal help om finansiële hulpbronne te verseker, beleggings te mobiliseer en beleide te hervorm. Kern lesse wat geleer was uit hierdie studie sal ook bewysgebaseerde advies verskaf vir beleidsontwikkeling en besluitnemingsprosesse wat poog om natuurlike ekosisteme vir huidige en toekomstige geslagte te beskerm deur middel van ekologiese infrastruktuurbeleggings.

**Sleutelwoorde**: Ekologiese Infrastruktuur beleggings, befondsingsmeganismes, vennootskappe, Betalings vir ekosisteme Dienste, ekonomiese beleid, Natuurlike Hulpbronbestuur, beleidsadvies

## Acknowledgements

I would like to extend a huge gratitude to my supervisor Prof Karen Esler for her undying support, academic mentoring and supervision, patience and her networks.

I thank Dr Christo Marais for his insightful advice, knowledge and wisdom as a co-supervisor and a mentor. I highly appreciate his support in securing funding and the exposure to international platforms.

I thank my second co-supervisor Prof Theo Kleynhans, for his motivation, academic guidance and insightful ideas, his '*Academic gymnastics'* slogan has truly motivated me.

I am indebted and highly appreciative for all the academic wisdom you have all invested in me- this would have been impossible without you.

I sincerely thank the South African National Biodiversity Institute (SANBI) and Department of Environment, Forestry and Fisheries (DEFF) for providing funding for this project.

Thanks is due to my managers, Alex Marsh, Tanya Layne and Mahlodi Tau, for their support and for allowing me sometime out of the office to work on my studies. I really appreciate it.

I would like to thank these individuals for the insightful conversations and technical support:
Brent Abrahams, Rhoda Malgas, Jasper Slingsby, John Dini, David Le Maitre, Sarah Polonsky, Mlungele Nsikani and Thandi Puoane.

Thank you very much Laetitia Piers for assistance with the '*Opsomming*' translation.

Thank you Lukhanyo Kweyama, Bulelwa Dikana and Uyanda Zembe for administrative support.

I thank my colleagues in the office for consistently checking up on me.

Sithandile Ngxangxa and Vusumzi Ngxangxa thank you for accommodating me during Stellenbosch visits. You are true friends.

I thank my mother, sisters (Nomfundo and Zivumile) and brothers (Balungile, Mncedi, Baphe and Aviwe) for their understanding and emotional support.

I would like to thank Keneilwe Hlahane (SAEON) for her moral support and taking time to read and comment on my sloppy drafts.

I am grateful to God for his blessings to have walked this journey to its end.

## Dedications

I would like to dedicate this work to my mother Nozolile Mbopha, my late father, Xolani Mbopha and my late brother Makhosana Mbopha, I will forever appreciate your undying efforts to make means for us to go to school.

"*Ndiyabulela Jali, Mbenya, Krakrayo, Mbeny'ezikrakra njengeTshongwe, Mpukw'enkone Mkhos'omde Ophika neLanga"*

*AmaJali Amakhulu!!!!*

*"Ndibulela kuni Mikhonde, Gadula, Ntikili Nosokani, Sikhond'esikrakrayo esakrakr'elumfaz'emithi. Maxhel'inkom'ingafi ife ngomso"*

**Table of Contents**

## List of tables

**List of figures**

# Chapter One: Introduction

Ecological Infrastructure (EI) refers to a suite of "naturally or semi-naturally functioning ecosystem that delivers valuable services to people; for example, healthy mountain catchments, rivers, wetlands, coastal dunes, nodes and corridors" (Lee et al. 2014; SANBI 2014a; Cumming et al. 2017; Kubiszewski et al. 2017). Degradation of Ecological Infrastructure has become a global reality of the twenty-first century, and measures to mitigate its severity have become urgent and a priority for governments and conservation organisations internationally (Lambooy and Levashova 2011). However, regardless of the fact that there are global conventions, initiatives and platforms dedicated to conservation and associated Ecosystem Services (ES), the current efforts to conserve have proved to be inadequate (Lambooy and Levashova 2011). Investments made in Ecological Infrastructure remain chronically insignificant despite its recognised importance (Iranah et al. 2018; Roberts et al. 2018). Amongst many approaches that could help to provide necessary resources, repeated calls have been made globally to get both private and public sector to share joint responsibility of managing and conserving Ecological Infrastructure (Sullivan 2013).

The South African government is mandated by its constitution to ensure that citizens have a clean and safe environment where ecological degradation is prevented and natural resources are used sustainably, whilst promoting biodiversity conservation (Constitution of the Republic of South Africa 1996). This constitutional prerogative steered the formation of the Working for Water (WfW) programme in 1995. This programme aimed to control Invasive Alien Plants (IAP) in order to protect a variety of Ecosystem Services such as water resources, rangeland productivity, biodiversity, and simultaneously to create employment (van Wilgen et al. 2001; Marais and Wannenburgh 2008; van Wilgen and Wannenburgh 2016). WfW subsequently evolved into the broader Natural Resources Management (NRM) programme to ensure environmental management, conservation and protection towards sustainability whilst responding to local communities' socio-economic needs (Department of Environmental Affairs 2012). The mandate of the NRM programme is three-fold: 'contribute to economic empowerment, social equity, and ecological integrity'. To achieve this mandate, the NRM programme works with local communities to identify local opportunities (Skills development and employment) that will assist them through ecosystem-based management interventions (Marais and Wannenburgh 2008).

A major portion of NRM funding comes through the Extended Public Works Programme (EPWP), which is primarily intended to address poverty alleviation (Turpie et al. 2007). This funding aims to achieve social and economic development (poverty eradication) and conservation outcomes (van Wilgen et al. 2011). Relying on EPWP funding to implement the NRM programmes

is deemed to be unsustainable because conservation outcomes become a side effect of poverty eradication intervention (Turpie et al. 2007). Sustaining NRM programmes requires more than the available funds to concentrate on the restoration of degraded landscapes and ecosystem services delivery (Shackleton et al. 2017). Acknowledging this funding gap and unsustainable dependence on EPWP funding enthused NRM programme managers to explore alternative mechanisms to 'unlock and secure Ecological Infrastructure investments' in order to counteract the resource shortfall (Turpie et al. 2007). The first mechanism was to develop legislative frameworks to compel private landowners to be responsible for seed pollution (occurrence and subsequent establishment of invasive alien plant seeds beyond demarcated areas without cultivation), alien invasion and internalise associated costs and risks (van Wilgen et al. 2012). The legal frameworks in place are: the Conservation of Agricultural Resources Act, 1983; the National Veld and Forest Fire Act, 1998; and the National Environmental Management: Biodiversity Act, 2004. The second mechanism was a Land User Incentives (LUI) model to incentivise private landowners to encourage land management and managing invasive alien plants (van Wilgen et al. 2012). Although these mechanisms are in place, an improved understanding of public and private cooperation and collaboration to achieve conservation goals remains limited (Cumming et al. 2017). Poor integration of economic instruments when conducting NRM studies contributes to the funding gap (Marais and Wannenburgh 2008). Hence the review of international Ecological Infrastructure investment mechanisms to provide evidence-based policy advice for South African decision makers is vital.

## Ecological Infrastructure metaphor

The term Ecological Infrastructure (EI) is largely used in South Africa, the synonymous concepts used in scientific literature to refer to EI are: Ecosystem Infrastructure, Environmental Infrastructure, Green Infrastructure, Natural Infrastructure or Natural Capital or Blue Infrastructure (Cumming et al. 2017; da Silva and Wheeler 2017). From an economic perspective, Ecological Infrastructure is a natural asset that is equivalent to built-infrastructure, which is intended to provide socio-economic services (e.g. power supply) for the improvement of human welfare (Doko et al. 2016). Given the need to secure public and political interest, and financial support for nature, the metaphor of EI emerged as an appropriate communication tool to be adopted (Maze et al. 2013). Maintaining and preserving healthy Ecological Infrastructure is essential to South Africa in order to achieve among others, social, water and food security, thus realising the Sustainable Development Goals (SDGs) each of which the National Development Plan 2030 (NDP) defines specific related development priorities for South Africa (Cumming et al. 2017).

## Ecosystem Services

Ecosystem Services (ES) is one of the modern conservation buzzwords used to describe the conditions and processes through which EI, and the species that compose them, sustain and fulfill human life. Biodiversity maintains these services and the production of ecosystem goods (Costanza et al. 1997, 2011; MEA 2005; Wallace 2007; Fisher et al. 2009; De Groot et al. 2013; Kull et al. 2015). The ES concept emphasises human reliance on nature, including economic products (Meyer et al. 2016), and supports decision makers to develop impactful conservation policies which enhance human welfare and the Sustainable Development (SD) agenda (Elmqvist et al. 2010; Kull et al. 2015; Costanza et al. 2017). The Millennium Ecosystem Assessment (MEA) (2005) produced the scientific knowledge on how ecosystems impact human well-being and also established the interventions required to maintain and sustainably conserve ES (Table 1.1).

Table 1.1. A description of how the four categories of ecosystem services add value to human livelihoods.

| **Ecosystem Services** | **Description** |
|---|---|
| *Provisioning services* | In combination with human, constructed and social capital, these services produce the raw products derived from ecosystems, such as food, freshwater, fuelwood, biological chemicals, genetic resources, etc. |
| *Regulating services* | These are the benefits derived from the regulation of ecosystem processes. In combination with human, built and social capital, these services include flood control, climate regulation, water regulation, water purification, disease control and regulation, pollination facilitation, and air quality maintenance. These services are commonly non-market although they add value to humans. |
| *Cultural services* | These are non-materialistic benefits derived from ecosystems; for example, aesthetic, recreation, spiritual and religious, cultural heritage and eco-tourism. They are closely bound to human values and behaviour, therefore, the value of cultural services is bound to vary or contradict among societies. |
| *Supporting services* | These services maintain primary ecosystem processes and functions, for example: soil foundation, carbon fixation, and habitat formation for fauna. They are essential for the production of all other Ecosystem Services. These may be considered as functions since they may be used as proxies for other services in other categories. |
| Sources | (MEA 2005; Wallace 2007; Fisher et al. 2009; Farley and Costanza 2010; Costanza et al. 2014; Crafford and Hassan 2014; Leventon et al. 2017) |

Note: This framework was originally developed by the Millennium Ecosystem Assessment in 2005 as a metaphor to demonstrate social reliance on ecosystems (Gómez-baggethun and Muradian 2015).

The above classification describes Ecosystem Services and the common factor is the contribution to human welfare (Table 1.1) (Costanza et al. 2011). The Ecosystem Services concept has been significant for landscape management, sustainable practice and decision making, because it integrates ecological and economic concepts to tie human economy with ecological systems and dimensions (Costanza et al. 2011, 2017).

## Threats to Ecological Infrastructure

Increasing rates of Ecological Infrastructure degradation are destabilising and threatening the natural flow of Ecosystem Services and Goods. In the end, the viability of socio-economic returns (e.g. human well-being) will be detrimentally impacted and ecological integrity will be compromised if degradation continues at the current rates. Degradation of Ecological Infrastructure, as well as loss of biodiversity, climate change, pollution, and loss of natural resources have become a serious concern to many conservationists (Ostrom and Cox 2010). The Millennium Ecosystem Assessment (MEA, 2005) conceptual framework identified the following ecosystem degradation drivers at a global scale: "primary *versus* proximate, anthropogenic *versus* biophysical, dependent *versus* independent, and primary *versus* secondary". Consequent threats include, but are not limited to: habitat loss and fragmentation, alien invasion, over-harvesting, unsustainable utilisation of timber and other forest resources, and unsustainable agricultural practices (MEA 2005).

The MEA framework indicated that human influence on Ecological Infrastructure is visible, particularly at a local level where people living within an ecosystem transform the state of ecosystems. The transformation reduces Ecological Infrastructure's ability to provide essential Ecosystem Services and poses considerable economic and social repercussions, and this is likely to be a key challenge (Polasky et al. 2008). A typical example in South Africa is the large and growing environmental problem of invasive alien plants which negatively impact on biodiversity and Ecosystem Services delivery, causing a significant and complicated conservation problem (Richardson and van Wilgen 2004; Marais and Wannenburgh 2008).

## Ecological Infrastructure investments

Exploring Ecological Infrastructure investment opportunities is essential to achieve ecological restoration objectives (Blignaut and Aronson 2008; Tschirhart 2009; Iftekhar et al. 2016) and to maintain Ecosystem Services for present and future generations (Marchant 2014). Investing in Ecological Infrastructure requires a commitment of resources in anticipation of returns and net-benefits in the future (Polasky et al. 2005). Generally, government institutions and the private sector (e.g. conservation Non-Governmental Organisations, corporates and environmental departments) invest resources for different motives: (1) profitability-investors expect their money back, often with interest; (2) they expect a positive change driven by the investment and (3) there is an intention to catalyse and attract other investors to address declining resource available. In the context of Ecological Infrastructure investments, resources invested may not promptly

generate financial returns but could be catalytic in enhancing environmental sustainability. For example, NRM invests in EI to optimise ecological integrity and alleviate poverty. These investments generate no direct financial income therefore they are not commercially viable. However, these investments add value to human upliftment and environmental protection (net-benefits). For that reason, expenditure is financially defensible for public expenditure and investments.

## Viewing Ecological Infrastructure through an economic lens

Ecological Infrastructure is characterised as a public good which supplies Ecosystem Services and benefits to an entire society, largely regardless of whether or not the society is keen to pay to enjoy these services and benefits (Kopsidas and Hadjixenofontos 2018). Over the past two and a half decades, NRM has invested social funds (~R 7 ,9 billion) through ecosystem-based management interventions to protect the Ecological Infrastructure, enhance the flow of Ecosystem Services, and increase socio-economic benefits in both public and privately owned landscapes (van Wilgen and Wannenburgh 2016). These interventions have been autonomously financed by National Treasury, without substantial contributions from the business or private sector (such as private landowners and private companies). The NRM interventions are justified on the basis of internalising negative ecosystem externality costs arising from both natural events and anthropogenic economic operations. Internalising negative externalities has been supported by environmental scientists and heterodox economists (socialist economists) concerned with Ecological Infrastructure loss in order to transform capitalism (Kull et al. 2015).

Several studies (Hawken et al. 1999; Farber et al. 2002; Ostrom and Cox 2010; Blignaut and Elst 2014) have concluded that economic practices tend to degrade Ecological Infrastructure severely, yet economics poorly addresses this loss. As a result, economists have recommended an integration of economic and ecological models in order to respond to this crisis (Higgins et al. 1997; Bishop et al. 2009; Tschirhart 2009). The private sector has been put under pressure by governmental policies to invest in Ecological Infrastructure because of the negative impacts caused by their economic activities (Houdet et al. 2012). The application of economics in conservation is further substantiated by: (1) the need to understand the root cause of ecological loss and degradation, (2) the need to decide how much conservation is applicable, and (3) for accurate resource allocation to conservation (Farley 2010). Integration of economics helps establish Ecological Infrastructure conservation strategies and sets priorities to allocate insufficient conservation resources according to Return on Investments, (maximise intervention benefits with less resources spent) (ROI) (Polasky 2008).

## Ecological Infrastructure Investment models: A precis for review

In this thesis, a European EI investment model, known as Agri-Environment Schemes (AES), is reviewed to draw lessons to optimise public and private partnerships that might improve EI investment responsibility in South Africa (data chapter one). Both AES and NRM investment models have been commonly established by European and South African governments respectively for Ecological Infrastructure conservation and Ecosystem Services delivery. The AES investment model was chosen for review on the basis of its good reputation and because through it, substantial resources have been dedicated to farmland sustainability by European governments (Kuhfuss and Subervie 2018).

Both AES and NRM investment models (through EPWP) encourage and support conservation programmes to protect the natural environment and to reduce agricultural impact; however, the integration of economic instruments to optimise efficiency and cost-effectiveness performance remains understudied. Obstacles to successful AES include poor monitoring, the prescriptive nature of the scheme, inflexible reimbursements, poor prioritisation of ecological results (Herzon et al. 2018), baseline data shortage, and methodological difficulties (Kleijn et al. 2006). Despite the aforementioned obstacles, funding shortage is not constraining AES towards its goals due to favourable economic development and conditions, in contrast to NRM. To advance NRM investment interests, this study aimed to learn from global AES experiences by understanding institutional support mechanisms, policy dimension and context that might be adopted in an attempt to ‘unlock and secure Ecological Infrastructure investments’, thereby addressing the current status of insufficient financial support dedicated to EI maintenance and restoration in South Africa.

The concept of Payments for Ecosystem Services (PES) has been chosen as a second investment mechanism for a systematic review. Globally, PES have a prominent reputation for being cost-effective; introducing new sustainable instruments for natural resource management; a win-win governance and policy tool to advance a socio-economic development agenda whilst achieving Ecological Infrastructure restoration and maintenance goals and for sustainable development outcomes despite a number of difficulties (Martin-Ortega et al. 2013; Carter et al. 2014). Although PES schemes have received socio-economic and ecological recognition, these schemes have faced substantial criticisms (Chan et al. 2017). In this study, I characterise the successes of PES schemes as well as challenges and failures associated with PES programmes to pull insights and lessons to improve investments in Ecological Infrastructure in South Africa

(data chapter two). AES are also considered as PES, however, AES will be excluded when reviewing this chapter.

## Research Methodology

The Systematic Literature Review (SLR) research approach was employed to comprehensively identify, evaluate, capture, synthesise and summarise studies, based on multiple threads of evidence in a highly standardised and reproducible manner (Sterling et al. 2017; Kohl et al. 2018). Comparative to traditional review methods, Systematic Literature Review presented rigorous methods that applied bias mitigation techniques, including inclusion of grey literature and snowballing (Haddaway 2015). The benefit of using systematic review is that it provides a guiding framework with a series of stages which inform a selection process. These include: planning and conducting literature evaluation; creation of a Systematic Review Protocol; search strategy; data extraction; data inclusion and exclusion criteria; data analysis and synthesis (Pullin and Stewart 2007). There are major benefits for conservation in utilising this research approach because it provides a synopsis of the best accessible evidence to inform policy, research and practice in nature conservation (Sutherland et al. 2004; Bayliss et al. 2016). ATLAS.*ti* (v8.4) software was used to conduct qualitative data analysis. It enabled a visualisation of relations between the studied elements that emerged from the analysed data. ATLAS.*ti* is regarded as an essential utility for qualitative analysis, particularly for larger bodies of textual data.

## Problem statement

The South African government must allocate its limited resources amongst many sectors and competing programmes to address socio-economic and environmental concerns. The Department of Environment, Forestry and Fisheries (DEFF) NRM programme funds Ecological Infrastructure restoration and maintenance programmes to achieve both conservation (ecological restoration and maintenance) and socio-economic (poverty alleviation and job creation) goals on one budget. Expanding this nation-wide ecological and social investment footprint is hindered by resource insufficiency, declining and inconsistent funding dispersal or budget allocation (primarily aimed at poverty relief) (Angelstam et al. 2017) and poor integration of economic instruments and studies in NRM research (van Wilgen et al. 2001; Marais and Wannenburgh 2008). These challenges are further compounded by the fact that NRM programmes are autonomously funded by the government with no substantial support from private institutions. However, the demand for Ecological Infrastructure restoration and maintenance is estimated to be six times higher than NRM's accessible resources (Giordano et al. 2012). To date, a gap remains in terms of practical

economic policy guidance and evidence-based knowledge about other impactful funding mechanisms and strategies to adopt when 'unlocking and securing Ecological Infrastructure investments'.

## Rationale of the study

The rationale of this study was to contribute towards a better understanding of Ecological Infrastructure investment mechanisms. The study would advise NRM programmes through evidence-based policy advice. The review of international mechanisms of investments in EI and applicable funding models studied has the potential to inform South African policy makers about Ecological Infrastructure investment instruments. Understanding global cases claiming success, and the policy context used to enthuse societal Ecological Infrastructure management responsibility will be instrumental to the development of a conceptual framework for policy makers. This thesis documented valuable lessons learnt where government, in conjunction with private institutions, collaborated to assume a collective Ecological Infrastructure conservation responsibility. Results of this study would inform the NRM's investment approach and help to optimise catalytic funding tools needed to upscale NRM work for better Ecosystem Services delivery in both public and private landscapes.

## Research statement

This exploratory review is primarily open-ended and guided by no hypothesis nor statistical test. It addresses the formulated research questions while it is open to emerging ideas. Collaborative partnerships between government and private landowners or users will optimise Ecological Infrastructure protection, maintenance, and restoration towards ecological integrity and Ecosystem Services delivery.

## Research aim

The overarching aim of this study was to contribute to the 'Unlocking and Securing Ecological Infrastructure Investments' concept by improving the understanding of potential investment mechanisms.

## Objectives

The objectives of this study were to:

1. review international literature on developmental needs and desires that inspire private landowners to accept responsibility for Ecological Infrastructure protection and conservation;

2. assess the policy context that stimulates collaboration and cooperation amongst government and private landowners towards Ecological Infrastructure investment;
3. review successes, challenges, and failures of implementation of Payments for Ecosystems Services (PES) as a conservation mechanism; and
4. draw lessons and insights from government and private cooperation and institutional support mechanisms for South African Ecological Infrastructure investment policy advice.

## Research Questions

1. What are the developmental needs that drive private landowners to realise the importance of investing in Ecological Infrastructure to protect their land?
2. What international means or contributions (Investment willingness) have been made to counteract natural resource degradation by private landowners?
3. What were the global policy instruments and tools that were formulated to encourage collaborative partnerships between government and private landowners towards Ecological Infrastructure protection?
4. What elements optimised, complicated and hindered the execution of Payments for Ecosystems Services towards conservation outcomes and ecological integrity?
5. What valuable lessons could be learnt from the findings to the above questions when providing evidence-based policy advice for investments in Ecological Infrastructure restoration, maintenance, and resource mobilisation?

## Study limitations

This study was not intended to review every Ecological Infrastructure investment model, but only models selected for their high reputation and recognition as win-win policy tools, and potential vehicles to enhance ecological integrity. The results may produce generalisable lessons; however, most are meant for South African NRM programmes and Ecological Infrastructure investment efforts.

## Thesis outline

### Chapter One: Introduction

This chapter describes the background of Ecological Infrastructure. It identifies threats to EI, benefits of investing in EI, and outlines the ongoing efforts to invest in Ecological Infrastructure. The problem statement, rationale of the study, research methodology, aim, objectives, and research questions are described here.

**Chapter Two: Unlocking and Securing Ecological Infrastructure Investments: the needs and willingness to invest and institutional support mechanisms used**

This chapter reviews the developmental needs and drivers which necessitated investments in Ecological Infrastructure. A review of the investment desire and willingness to participate and contribute to investment efforts is presented in this chapter. The policy dimension and institutional support mechanisms used to encourage cooperation and partnership between government and private landowners are reviewed and examined. Lessons learnt are drawn at the end of the chapter.

**Chapter Three: Systematic Literature Review of PES successes, failures and challenges**

In this chapter a review is presented of the successes, failures, and challenges experienced in the implementation of Payments for Ecosystem Services as a market-based conservation instrument. It describes the institutional, social, economic and ecological performance of PES successes, failures and challenges. Lastly, it outlines the lessons learnt for policy development and efforts to design and implement better PES programmes.

**Chapter Four: Conclusion**

Synthesis of key findings and lessons learnt from the entire systematic review are consolidated. Recommendations are made for evidence-based policy advice necessary for Ecological Infrastructure investments. Concepts and grey areas warranting further research are outlined.

**Appendices**

The appendices provide extended data and information on the research methods, findings and other supporting materials used.

# Chapter Two: Unlocking and Securing Ecological Infrastructure Investments: the needs and willingness to invest and institutional support mechanisms used

## Abstract

Ecological Infrastructure (EI) is a natural and near-natural functioning ecosystem that delivers a range of essential services to humankind. Examples include catchments, wetlands, coastal dunes, and riparian corridors. In a world where Ecological Infrastructure is underinvested, rapid degradation and threats such as unsustainable veld fire regimes, droughts, climate change, and invasive alien plants persist in dominating the ecological landscape. Government restoration programmes have been introduced to encourage protection of Ecological Infrastructure. However, inadequate funding allocation for the maintenance and restoration of Ecological Infrastructure nationwide has led to the need to scale up and unlock public and private sector investments in order to augment ecosystem-based management interventions. For this study, a systematic literature review was conducted at a global scale to (1) understand the drivers behind decisions to invest in Ecological Infrastructure, (2) understand the willingness and desire of private landowners to participate and contribute to EI investments and (3) identify institutional support mechanisms in place to encourage investments. Results suggest that the need to invest is driven by degradation of Ecological Infrastructure and the urgency to meet environmental sustainability goals. The willingness to invest and to participate is stimulated by the use of economic-based policies and compensatory mechanisms. Public-private partnerships, public policy, and market-based conservation instruments are institutional arrangements executed to protect Ecological Infrastructure. These include processes and systems used by the institutions to legislate and manage interventions towards fulfilling the conservation objective. The study contributes to the EI investment research agenda by recommending coordinated efforts to encourage EI investment from both public and private partners. These measures will help to secure financial resources, mobilise investments beyond monetary terms by coordinating planning and developing capacity and reform policies.

## Introduction

‘South Africa is the third most biologically diverse country in the world’ (Gallo et al. 2009; SANBI 2014; West et al. 2016) with a wide range of important ecosystems which deliver essential services to support humankind. Concerns about the rapid rate of environmental degradation and potential effects on society have triggered a need for substantial investment efforts to counteract

such impacts whilst advancing Sustainable Development Goals (SDG) and the National Development Plan (NDP) agenda (The NDP maps out specific development priorities for South Africa to reach by 2030. Examples of targets include commitments to reduce poverty and inequality; raise employment and investment; bolster interventions to ensure environmental sustainability and resilience to future shocks, etc.) (Cumming et al. 2017). To respond to this challenge, the South African government instituted Natural Resources Management (NRM) programmes to protect and preserve natural assets in conjunction with a poverty alleviation approach. This initiative was born through a constitutional imperative to safeguard the state's natural resources for the benefit of current and future generations (Constitution of the Republic of South Africa 1996). Considering the legacy of the socio-political regime and injustices of the past, the NRM programmes diversified their resource management approach by prioritising the creation of socio-economic opportunities for previously disadvantaged groups. Due to joint goals of job creation and poverty reduction, the NRM programmes are funded by the National Treasury (Extended Public Works Programmes-EPWP) which is primarily intended to support poverty relief programmes. As a result, NRM programmes focus on job creation and poverty reduction while maintaining and restoring Ecological Infrastructure. The NRM programmes established operational support mechanisms to play an advisory role in its functions and core mandate (Angelstam et al. 2017). The MaReP forum (Managers, Researchers and Planners forum) is one of the arms used to ensure that NRM managers, researchers, and planners are collaborating effectively, communicating and establishing active partnerships to achieve NRM goals (Angelstam et al. 2017). Through the MaReP forum, the concept of 'Unlocking and Securing Ecological Infrastructure Investments' was raised.

The term 'Ecological Infrastructure' refers to a natural or near-natural functioning ecosystem that delivers essential services to humankind. Examples include healthy mountain catchments, rivers, wetlands, coastal dunes and riparian corridors (Lee et al. 2014; SANBI 2014b; Cumming et al. 2017). The Ecosystem Services (ES) supplied by this Ecological Infrastructure may be regarded as equivalent to socio-economic services (e.g. electricity supply and health services) which are derived from built-infrastructure. These Ecosystem Services (ES) are classified into four main groups: *Supporting* (for example nutrient cycle, primary production), *Regulatory* (e.g. disaster mitigation, water purification), *Cultural* (e.g. spiritual values, aesthetics) and *Provisioning* (e.g. food, water) services (MEA 2005; Fisher et al. 2009; Farley and Costanza 2010; Costanza et al. 2011). The concept of Ecological Infrastructure gained prominence in the NRM discourse because it carries an economics argument, which is essential to attract public attention for ES support and recognition through public and conservation policies (Bishop et al.

2009; Maze et al. 2013). Furthermore, this concept has the advantage of opening up conversations with the investment world too because it is a new generation of infrastructure essential to achieve developmental objectives such as water security, poverty reduction, disaster risk reduction and resilience to climatic changes (Browder et al. 2019).

## Investments in Ecological Infrastructure through NRM

Invasive Alien Plants (IAP) present a growing threat to Ecological Infrastructure, biodiversity and Ecosystem Services delivery (Le Maitre et al. 2002; Richardson and van Wilgen 2004; Holmes et al. 2005; Lange and Wilgen 2010). In response, the Department of Environment, Forestry and Fisheries (DEFF) through the NRM programmes, invests in Ecological Infrastructure restoration and maintenance projects to enhance Ecosystem Service delivery, whilst empowering and capacitating those employed on NRM programmes (Le Maitre et al. 2002; Marais et al. 2015). The NRM investment model uses incentives and disincentives [Land User Incentives (LUI)] to encourage private landowners to manage and protect Ecological Infrastructure on their private land (Cullis et al. 2007; Department of Environmental Affairs 2012; van Wilgen and Wannenburgh 2016; Shackleton et al. 2017). Service providers are appointed to implement ecosystem-based management interventions (Turpie et al. 2007). This approach aims to facilitate ownership of the repair of degradation by both private landowners and the NRM programme through cost-sharing, broadening engagement with stakeholders and partnering with local authorities to encourage policy compliance (Blignaut et al. 2007; Cullis et al. 2007; Department of Environmental Affairs 2012; van Wilgen et al. 2012). Cost-sharing and strong collaborative engagements are deemed essential to minimise the cost burden, particularly since NRM funding is constrained. In 2012, the demand for financing nation-wide ecosystem-based management interventions was estimated to be six times more than available resources (Giordano et al. 2012) and constant and long-term support for interventions is a costly exercise.

The current South African conservation legislative framework (for example the Conservation of Agricultural Resources Act, 1983; the National Veld and Forest Fire Act, 1998; the National Environmental Management: Biodiversity Act, 2004) requires private landowners to be primarily responsible for Ecological Infrastructure protection (such as land management, invasive alien plant clearing, ecological restoration, fire management, etc.) on their private land. Despite these legal requirements being in place, the contribution of private landowners towards public good investment is still insignificant (Turpie et al. 2007). Acknowledging this gap, a well-subsidised and theoretically reputable investment model collectively known as Agri-Environment

Schemes (AES) (Wilson et al. 2007; Dal Ferro et al. 2016) was chosen as a comparable model to extract lessons essential for NRM guidance on policy advice and operational matters.

## The context of Agri-Environment Schemes

Agri-Environment Schemes (AES) are major sources of nature conservation funding in Europe, Australia and United States of America (Batáry et al. 2015; Meyer et al. 2016; Zimmermann and Britz 2016; Kok et al. 2018). They respond to agricultural impacts that threaten species, ecosystems and Ecosystem Service delivery (Kleijn and Sutherland 2003; Batáry et al. 2015). AES encourage farmers to protect Ecological Infrastructure and reduce ecosystem degradation pressures on farmlands through the implementation of specific Agricultural Environmental Measures (AEMs). AEMs are any environmentally friendly farming methods that supply Ecosystem Services. Farmers are financially incentivised for implementing AEMs (Kleijn et al. 2006; dos Santos et al. 2015; Taylor and Grieken 2015; Meyer et al. 2016). Approximately £25 billion (~R457 billion, May 2019) is dedicated to AES in Europe (Zimmermann and Britz 2016; Herzon et al. 2018), but despite the substantial funding, AES have poorly mastered cost-effectiveness to improve implementation. Schemes are also challenged by a dearth of baseline data and rigid repayment arrangements (Kleijn et al. 2006). Also, little effort has been made to measure and monitor ecological outcomes delivered by AEMs (Herzon et al. 2018). Pressure to focus on the evaluation of the interventions is growing (Hajkowicz 2009), due to doubts about effectiveness and efficiency of AES (Kuhfuss and Subervie 2018).

This study was driven by the realisation that NRM's insufficient funding is linked to the reliance on one funding source and absence of other potential investors in the Ecological Infrastructure discourse (van Wilgen et al. 2001; Turpie et al. 2007; Marais and Wannenburgh 2008). Growing concerns posed by unsustainable veld fire regimes, droughts, climate change, and invasive alien plants, floods, loss of Ecosystem Services on South African Ecological Infrastructure have further stimulated efforts to understand the possibilities of supplementary funding streams. A systematic literature review was therefore conducted to explore (1) the developmental needs or drivers necessitating Ecological Infrastructure investments, (2) the willingness of private landowners to participate and/or contribute towards Ecological Infrastructure maintenance and restoration measures on their land and (3) the role of government support, policy regime and institutional arrangements to stimulate co-operation and shared responsibility for Ecological Infrastructure protection. The aim is to provide evidence-based conservation policy advice to inform decision-

makers, scientists, policy-makers, NRM practitioners and various other stakeholders across conservation institutions about viable investment mechanisms to be explored when mobilising funds. Lessons and insights learnt from global experiences are presented to guide investment attempts.

## Methods

A Systematic Literature Review (SLR) research methodology was chosen to gather scientific and non-scientific information (Pulling and Knight 2001; Pullin and Stewart 2007) to inform and advise the NRM policy interventions. The literature review was conducted at a global scale to access broader information. The following procedures were undertaken. Firstly, a Systematic Review Protocol (SRP) was developed to define the objectives of the review, to develop review questions, and to set criteria for inclusion and exclusion of sources and keywords (Dempster, 2003) (Appendix 1). The SRP described data extraction and synthesis methods. A PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) workflow was developed to show the selection and assessment of collected sources during SLR as per PRISMA requirements (Figure 2.1) (Moher et al. 2009). Search terms were then created to extract sources from peer-reviewed (Web of Science, Scopus, Science Direct) and grey literature databases (Google and the search bubble effect where Google recommended and personalised the results according to the user preference) (Table 2.1). A pilot search was conducted prior to the definite search to improve the search strategy. The search strategy was then broadened to identify, evaluate and summarise all eligible sources where there were (1) driving needs to invest in Ecological Infrastructure (2) indicators of willingness of private landowners to invest and the relations amongst the determinants of willingness and (3) emerging institutional arrangements where government and private landowners co-operated to invest in Ecological Infrastructure as well as recommendations for securing and unlocking investments.

The search terms were entered in combination with “Agri-Environment Schemes” in order to retrieve AES studies relevant to the NRM investment model. Truncated words, synonyms, alternative spellings, Boolean logic, and wildcards were used in the search strings. To minimise non-target articles, journals of less relevance to the searched topic were excluded (for example, engineering, political, medical, legal, health, etc. after scanning through their titles and abstracts). Search strings were customised based on different database specifications (Table 2.1), for example, Science Direct did not accept truncated words, as a result, they were entered in full. A “PICO” model was used to identify the Problem/Subject, Intervention, Comparison, and Outcome elements (Table 2.2). This literature search strategy tool further helped to define additional key

elements of the review (Cooke et al. 2012). The search was supplemented by a snowballing approach to gather more sources based on bibliographies of relevant articles, particularly for grey literature. Inductive (concepts emerging from the review process) and deductive (preconceived review concepts) coding methods were employed to extract thematic information from the literature. The limitation of my methodology is that I cannot fully guarantee the inclusion of every relevant study due to different languages and unavailability of full text resources of some sources.

Table 2.1. Combination of search strings used to compile literature on Ecological Infrastructure investments needs, willingness to invest, and institutional support mechanisms.

| *1. Needs and drivers for Ecological Infrastructure investment* | *2. Developmental willingness and desire of private landowners to invest in the maintenance and restoration of Ecological Infrastructure* | *3. Assessment of institutional support and policy mechanisms used to encourage the restoration and maintenance of Ecological Infrastructure* |
|---|---|---|
| "ecolog* infrastructur*" OR<br>"ecosystem* infrastructur*" OR<br>"environment* infrastructur*" OR<br>"soft infrastructur*" OR<br>"natur* infrastructur*" OR<br>"green infrastructur*" OR<br>"natur* capital"<br>NOT<br>"biolog* infrastructur*"<br>AND<br>"invest*" OR<br>"financ*" OR<br>"fund*"OR<br>"sponsor*"<br>"develop*" NOT<br>"investigat*"<br>AND<br>"need*" OR<br>"driv*" OR<br>"caus*" OR<br>"motiv*"<br>AND<br>"Agri-Environment Schemes" | "ecolog* infrastructur*" OR<br>"ecosystem* infrastructur*" OR<br>"environment* infrastructur*" OR<br>"soft infrastructur*" OR<br>"natur* infrastructur*" OR<br>"green infrastructur*" OR<br>"natur* capital"<br>NOT<br>"biolog* infrastructur*"<br>AND<br>"means*" OR<br>"capacit*" OR<br>"willing*" OR<br>"contribut*" OR<br>"resourc*" OR<br>"support*" OR<br>"develop*"<br>AND<br>"partner*" OR<br>"privat* landowner*" OR<br>"landown*" OR<br>"landhold*" OR<br>"farmland*" OR<br>"farmer*" OR<br>"stakeholder*"<br>AND<br>"Agri-Environment Schemes" | "ecolog* infrastructur*" OR<br>"ecosystem* infrastructur*" OR<br>"environment* infrastructur*" OR<br>"soft infrastructur*" OR<br>"natur* infrastructur*" OR<br>"green infrastructur*" OR<br>"natur* capital"<br>NOT<br>"biolog* infrastructur*"<br>AND<br>"polic*" OR<br>"polic* tool*" OR<br>"polic* instrument*" OR<br>"polic* framework*" OR<br>"legal framework*" OR<br>"polic* mechanism*"<br>AND<br>"partnership*" OR<br>"collaborat*" OR<br>"co?perat*" OR<br>"cooperat*"<br>"institution* support*"<br>AND<br>"Agri-Environment Schemes" |

Note: ***** shows the use of wildcards or truncated words to retrieve alternate word endings.

Table 2.2. PICO model: Population/Subject, Intervention, Comparator and Outcome search strategy tool defined the search themes in a timely and sensitive manner.

| | |
|---|---|
| **Population/Subject** | In all countries, Ecological Infrastructure (EI) in terrestrial and marine ecosystems. |
| **Intervention** | Investments in Ecological infrastructure: A process where various sectors collaborate, through policy objectives and practical actions to maintain and restore EI. Review the drivers of EI investments; the willingness of private landowners or stakeholders to invest and the institutional mechanisms established to encourage investments. |
| **Comparison** | Comparisons between South African EI Investment model (NRM) and other EI investment models in other countries (or Agri-Environment Schemes). |
| **Outcomes** | Studies documenting developmental needs and developmental desires to invest in EI and institutional support mechanism used to encourage EI investments. |

## Results

In total, 751 sources were retrieved from Web of Science, Scopus, Science Direct electronic databases and Google search engine. The sources were methodologically screened using the PRISMA approach (Figure 2.1); this phase focussed on reading the article title, keywords and abstract. Subsequently, duplicates were excluded and the remaining 218 sources were read diagonally (reviewed introduction, tables and figures, and conclusion) or in entirety depending on relevance. Sources were assessed for eligibility after some were excluded due to irrelevant subjects, investment models, comparators and results and ultimately the PRISMA sequence distilled the hits to 124. These sources were then imported into ATLAS.*ti* 8.4 (2018) for coding and qualitative analysis. Many sources used were obtained from relevant conservation journals (Appendix 2).

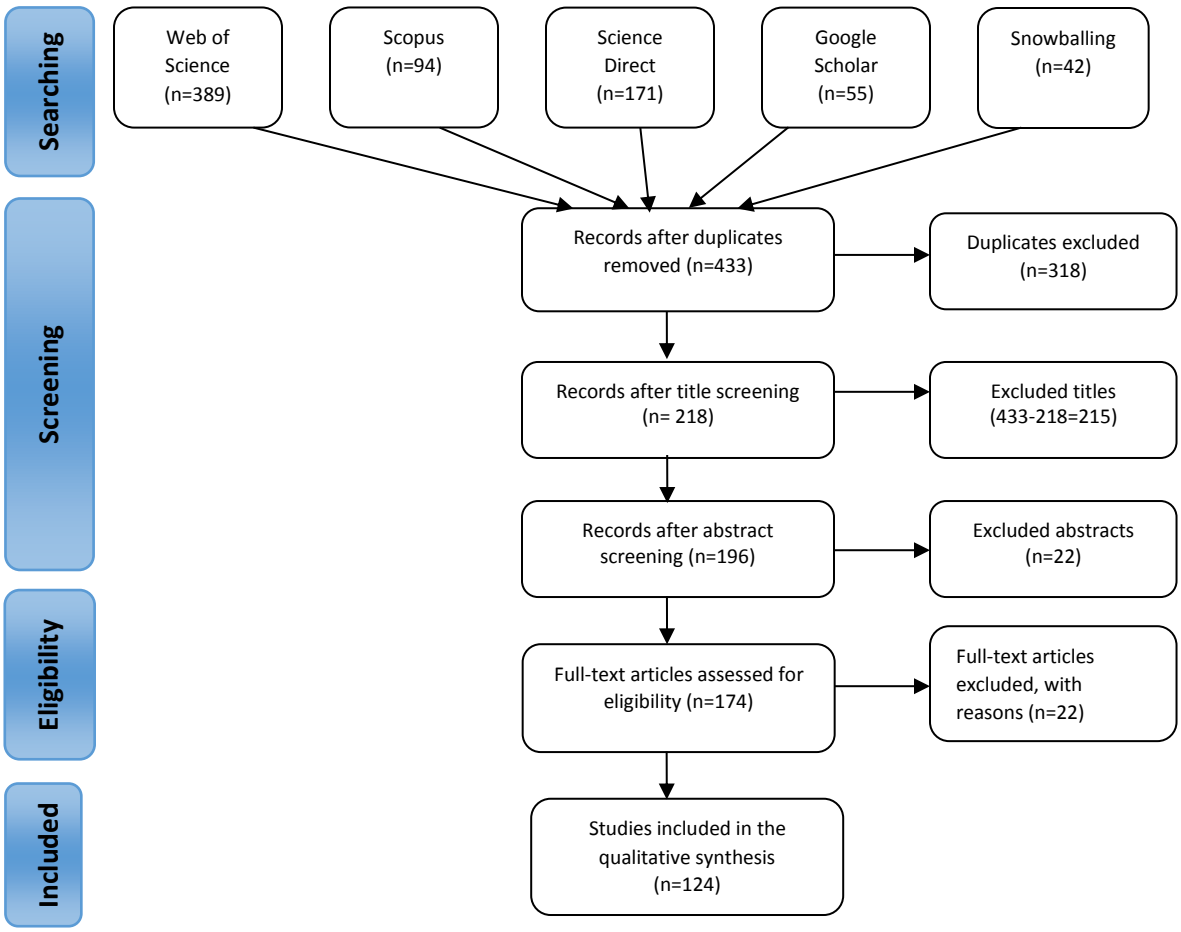



Figure 2.1. PRISMA diagram sketching the results of articles at searching and screening phases from different databases and sources.

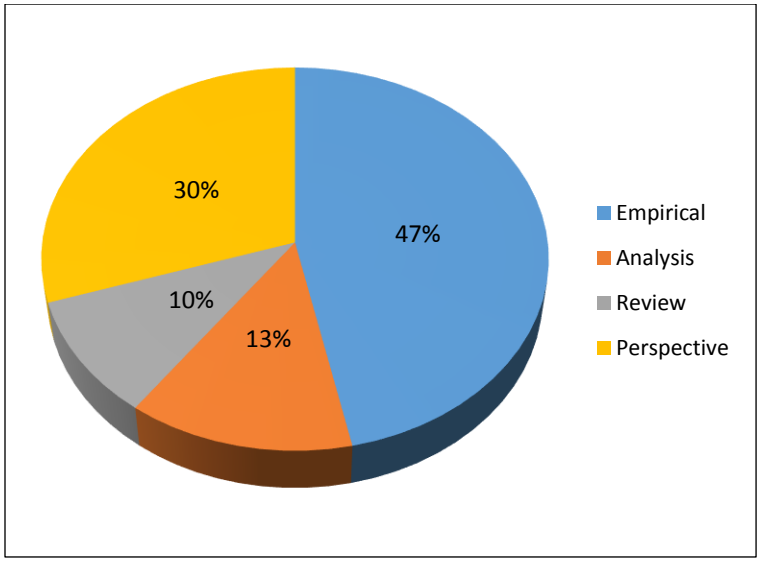



Figure 2.2. Study type: the proportion of selected studies which used different research methodologies.

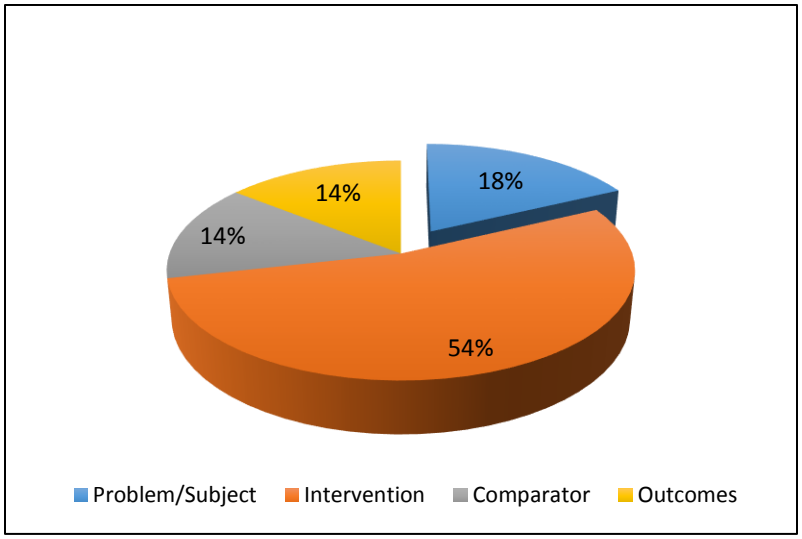



Figure 2.3. PICO model: the percentage of literature sources which studied different components of research question and strategy, some focussed on the subject, interventions, comparison, and the outcomes.

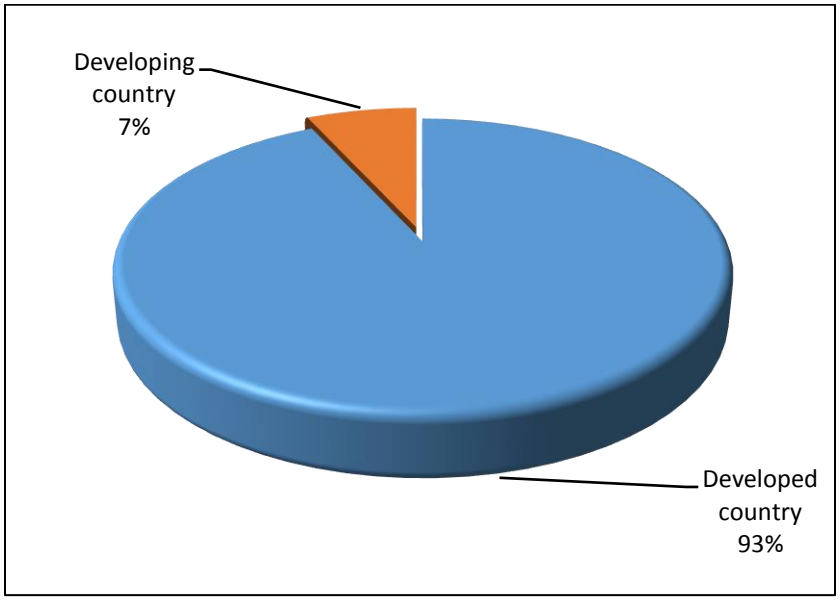



Figure 2.4. The percentage of reported literature on the use of institutional support mechanisms to encourage investments in Ecological Infrastructure protection in developing versus developed countries.

## Needs and drivers for investing in Ecological Infrastructure

Results showed that various drivers necessitate governments, non-governmental institutions and private sector (in some occasions civil society members) to take initiative to invest in Ecological Infrastructure (Table 2.3). The motives for investments varied (2.3 in ranks) depending on investor type and tenacious natural or anthropogenic pressures, for example, natural disasters induced by global climate changes and agricultural intensification (land-use and cover change). The need to protect and conserve biodiversity and to mitigate agricultural intensification are amongst the biggest drivers of investments in Ecological Infrastructure (Arponen et al. 2013). Investments are mainly driven by Government, Private Sector and Non-Governmental Organisations (NGO) respectively. Livelihood enhancement through Ecosystem Service (provision, regulatory cultural and support services) delivery while sustaining the Ecological Infrastructure is also an instrumental driver of investment. Other drivers included adapting and mitigating climate change and natural disasters to decrease their severity and water resource protection (Bennett et al. 2016). Government remains the leading investor to address all the categorised needs.

Table 2.3. The needs or drivers that necessitate investments in Ecological Infrastructure by different investors. Concept categories were derived from Atlas.*ti* coding of N=124 sources derived from the systematic review.

| **Concept category** | **Ecological Infrastructure investment drivers or needs** | **A frequency of mention (%)** | **Types of Ecological Infrastructure** | **Investors in ranks** | **Natural or anthropogenic pressure** |
|---|---|---|---|---|---|
| Biodiversity Protection | Enhancement and conservation of biodiversity<br>Eradication of invasive species<br>Protection of biodiversity on private land<br>Habitat protection and maintenance<br>Restoration of endangered ecological communities | 27% | Wetlands<br>Forests<br>Endangered species<br>Rivers<br>Ecological communities | Government<br>Private Sector<br>NGO | Natural and Anthropogenic pressure |
| Agricultural or agronomics | Mitigation of detrimental impacts posed on terrestrial and freshwater ecosystems due to agricultural activities<br>Address the impact of Land Use and Cover Change<br>Mitigate soil erosion | 25% | Terrestrial ecosystems<br>Freshwater ecosystem<br>Ecological landscapes | Government<br>NGO<br>Private Sector | Anthropogenic pressure |
| Ecosystem Services and human wellbeing | Protection of Ecosystem Services delivery (provision, regulatory cultural and support) | 20% | Terrestrial ecosystems<br>Wetlands<br>Biodiversity corridors | Government<br>Private Sector<br>NGO | Natural and Anthropogenic pressure |
| Climate change and natural disasters | Lessen drought caused by climate change scenarios<br>Reduction of Greenhouse gases<br>Minimise flood risk<br>Carbon sequestration<br>Wildfire risks and extreme disruptive events | 14% | Forests<br>Wetlands<br>Landscape/terrestrial ecosystems | Government<br>NGO<br>Private Sector | Natural and Anthropogenic pressure |
| Water management | Address storm-water challenges<br>Improvement of water quality and quantity<br>Protection of water catchments for biodiversity and human wellbeing | 14% | Rivers<br>Catchments<br>Wetlands | Government<br>Private Sector<br>NGO | Natural and Anthropogenic pressure |

## Willingness to invest in Ecological Infrastructure

The importance of understanding the desire and willingness of private landowners to adopt conservation practices, participate and contribute in Ecological Infrastructure investments is well recognised (Mills et al. 2018). This subsection reviews and assesses the willingness or desire of private landowners in conjunction with public institutions to accept investment responsibility. Factors associated with willingness determinants and how they relate to each other were also assessed. The reviewed studies indicated that private landowners' enthusiasm is influenced by five main determinants and the strength of the relationship between these determinants.

This study demonstrates that compensation measures (such as funding and other associated financial benefits) do encourage private landowners to participate and implement Ecological Infrastructure restoration and maintenance measures on their land (Russi et al. 2016; Weikard et al. 2017; Feng et al. 2018). Compensation measures are delivered through the application of Market-Based Conservation Instruments (MBCI), such as economic-based policies which incentivise participating private landowners to deliver Ecosystem Services and comply with the legislation (Figure 2.5). Socio-economic characteristics and advantages including land ownership, bigger land size, access to information, public awareness and advocacy were found to be significant in stimulating willingness to cooperate towards Ecological Infrastructure investment. Private landowners who are environmentally conscious, older, experienced in conservation and have a tertiary level education are more likely to participate and be the stewards of conservation (Figure 2.5. Conservation ethics, values and philosophy). Sensitive natural environments and distinctive features trigger conservation interest; Figure 2.5 shows that where there were unique environmental features such as endangered ecological communities, wetlands, marine assets, etc., more private landowners were keen to counteract degradation through investments and protecting a natural asset they value or rely on. Conservation activism displayed by civil society members and Non-Governmental Organisations also placed pressure on authorities and implicated landholders to make contributions towards investments.

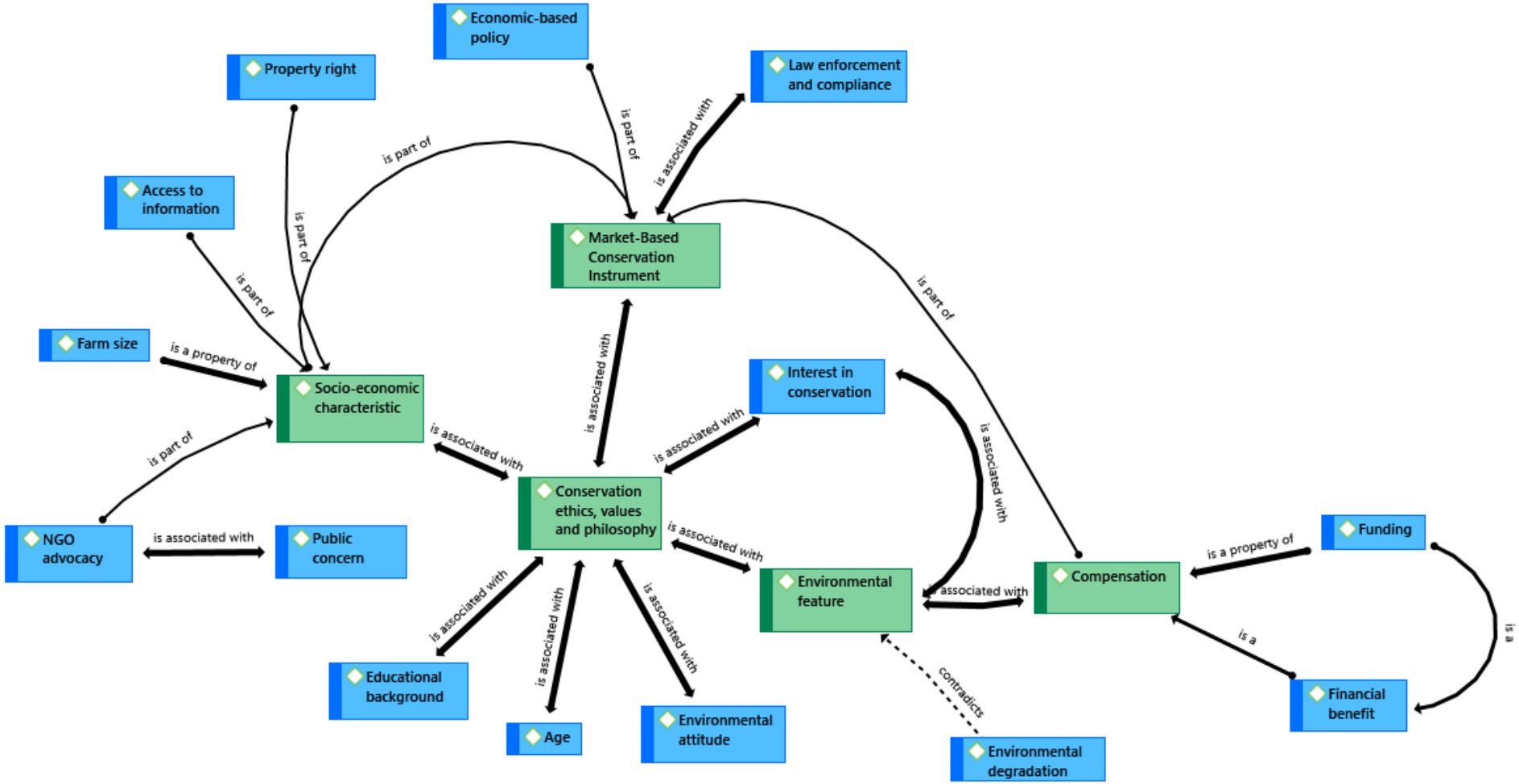



Figure 2.5. A Cognitive Map from the review of determinants of willingness to invest in Ecological Infrastructure by private landowners and other institutions.

Note: The key determining factors are presented in green boxes and the associated factors are represented in blue boxes. These determinants and associated factors emerged from the read sources, articles and journals (developed inductively). The linkages and relationships amongst all the key factors and supporting factors are described in arrows. The thickness of arrows and lines represent the strength of those linkages (through frequency of mention and association). The thicker the line the stronger and the thinner the lines the weaker the relationships.

## Institutional support mechanisms to encourage EI investments

### (a) Public policy

The review showed that public institutions and private landowners invest in Ecological Infrastructure through policy implementation, management, political support, and self-directed environmental awareness and support to advocacy by non-governmental organisations (Feng et al. 2018; Harrington and Hsu 2018). Generally, public policies emphasise regulatory enforcement and compliance which compel landowners to implement ecosystem-based management interventions in order to address EI degradation and ecosystem loss (Mcwilliam and Balzarova 2017; Asantewaa and Xavier 2018). However, policymakers are designing conservation strategies which incentivise landowners to execute sustainable land use practices that deliver Ecosystem Services, minimise environmental risks and maximise socio-economic development benefits (Bremer et al. 2016; Galbraith et al. 2017; Sheremet et al. 2018).

### (b) Lessons learnt from Agri-Environmental Schemes

Several experiences were drawn from the review of Agri-Environment Schemes. European Union state members formed incentive programmes to stimulate Ecological Infrastructure conservation and enhancement from farmlands (European Commission, 2013). Through Common Agricultural Policy (CAP), these programmes subsidise private landowners who voluntarily adopt and implement Agri-Environmental Measures (Hajkowicz 2009; de Krom 2017; Kok et al. 2018; Nielsen et al. 2018). Although AES are widely recognised as major instruments to curb degradation (Schroeder et al. 2013), some scholars criticise their efficiency to fully conserve the rural landscape (Latacz-lohmann and Hodge 2003; Kleijn et al. 2006). This criticism is due to the fact that conservation approaches focussing on individuals or farm level contracts are insufficient to achieve wider-landscape protection (Riley et al. 2018). AES have primarily focussed on incentivising private landowners to comply with schemes' norms and standards (Action-Based Measures). The emerging literature (Schroeder et al. 2013; Herzon et al. 2018) suggests that payments should be driven by the desired results (Results-Based Measures) (Russi et al. 2016). This implies that private landowners should receive financial rewards based on ecological outcomes produced, for example a set of indicator species conserved, proof of Ecosystem Services delivered by conservation interventions, beyond Ecological Infrastructure friendly practices (Schroeder et al. 2013).

**(c) Public-Private Partnerships**

Public-Private Partnerships (PPP) are used as cooperative mechanisms to mobilise funding for public goods and services (Glumac et al. 2015; Ferraza and Coutinho 2017; Zhang et al. 2018). They require effective collaboration between local authorities and communities, government agencies, private landowners, private investors, business sectors, non-governmental organisations and individual civil society members (Franks and Emery 2013; Welsh et al. 2018a). PPPs have grown rapidly and have become essential vehicles to encourage private sector investments in conservation (Hardy et al. 2018; Welsh et al. 2018b). However, the current role and commitment of the private sector in long-term arrangements is still insignificant. As a result, PPPs are not mobilising sufficient funding to alleviate Ecological Infrastructure degradation (Yang et al. 2010).

**(d) Market-Based Conservation Instruments**

Market tools, economic-based and funding mechanisms have been formed to enable ecosystem goods and services delivery, economic growth, and development while protecting Ecological Infrastructure (Zammit 2013). These funding vehicles are known as Biodiversity Banks or Conservation Banks (Froger et al. 2015; Guillet and Semal 2018). They are guided by different policy tools, systems, processes and procedures in different nations. Examples include mitigation biodiversity offsets, mitigation banking, habitat banking, species banking, wetland mitigation, etc. (Coralie et al. 2015; Lapeyre et al. 2015). Their fundamental purpose is to provide compensatory mechanisms in the form of investments to counterbalance degradation, damage resulting from economic practices and developments, and to support interventions that deliver conservation outcomes (Voora and Venema 2008; Zammit 2013; Froger et al. 2015; Lamarque and Lambin 2015; Vatn 2018). Investments accumulated are used for restoration, maintenance, conservation, and protection of Ecological Infrastructure and conservation of endangered species. Academics, conservation community and decision makers recognise conservation funds as Market-Based Conservation Instruments (MBCI) because they offer opportunities to create, restore, rehabilitate and conserve disturbed ecological habitats due to land use change or transformation (Hein et al. 2013; Froger et al. 2015).

Table 2.4. Financing tools and funding mechanisms used to promote Ecological Infrastructure investments through Market-Based Conservation Instruments.

| Finance tool/Funding mechanism | Description | Reference |
|---|---|---|
| Reducing Emissions from Deforestation and Forest Degradation (REDD+) | Greenhouse gas emitters pay a levy for forest protection. This funding tool monetises carbon stored in forests and incentivises developing economies for reduction of emissions associated with deforestation and to improve local communities' livelihoods. | Neilsen et al. 2018; Moros et al. 2019 |
| Global Environment Facility (GEF) | This grant is precisely designed to protect and conserve environmental and natural resources in the developing world. The investments come with financial and impact targets. They require collaborations to ensure long-term ecological and socio-economic viability. | NatureVest 2014; Cumming et al. 2017 |
| Mission Related Investments (MRI) | These are investments made by foundations to achieve their philanthropic missions. They are fundamentally part of the legacy and grant of the foundations and are likely to cause a positive socio-ecological impact. | Gartner et al. 2013; NatureVest 2014 |
| Climate Bonds/Green bonds | Green bonds have grown rapidly and they have grown finances or liquidity of Green Investments. They are offered by the World Bank to promote large-scale investments to support global low carbon and climate resilience. Ecological Infrastructure maintenance and restoration projects could be tagged on Green bonds, however, investment returns must be clear and tangible for the potential investor. | NatureVest 2014; DuPont et al. 2016; Clark et al. 2018 |
| Municipal bonds | Local municipalities could set aside bond which funds Ecological Infrastructure maintenance and restoration to reduce future liability in the event of catastrophic or flood events. Municipal bonds enable public institutions to borrow money from investors and repay it through tax or other revenue streams. | Spergel and Moye 2004; Browder et al. 2019 |
| Insurance products | Insurance companies could avoid severe cost through Ecological Infrastructure investments. For example, insurance companies have paid more than $200 billion (R29,7 billion-June 2019) in coastal flood damage in a decade ago. Risks could be minimised by maintaining and restoring Ecological Infrastructure. Better Ecological Infrastructure resilience would result in lower premiums. The government should work closely with the insurance industry to identify ways and products to enact this market. This further implies that companies making profits in ecological landscapes ought to be liable for any damages and pay through insurance covers. | Bos et al. 2015 |
| Conservation banking | Conservation/Biodiversity banks protect Ecological Infrastructure by counterweighing the anticipated ecological or habitat degradation due to economic development. They create net conservation benefits by maintaining, restoring, enhancing and preserving any form of Ecological Infrastructure such as wetlands, habitat or threatened or endangered species. | Hein et al. 2013; Boisvert 2015; Froger et al. 2015 |
| Corporate Sponsorship | Local businesses associate their products and brands with sustainable management of natural resources by contributing a certain portion of their revenue to natural resources management fund or investments. They position and brand themselves as socially and environmentally responsible and that attracts more clients to justify their price costs. | Gartner et al. 2013 |
| Development banks funds | Development banks finance governments in developing countries where finances are limited. Since NRM's approach to conservation promotes socio-economic development, development banks could be approached to provide finance. | Ferraza and Coutinho 2017. |

Note: This tables draws on the list of selected sources which presented specific insights (few are also found in the master database at the end) and details of the finance tools and funding mechanisms which have claimed success in financing Ecological Infrastructure projects across the globe.

# Discussion

This section interprets the implications of the results of the drivers of investments in Ecological Infrastructure, the willingness of private landowners to invest in Ecological Infrastructure and the support mechanisms in place to encourage investments. Lessons learnt and recommendations are presented at the end in order to inform and advise the natural resources managers and policymakers based on Systematic Review evidence.

## Needs and Drivers of Ecological Infrastructure investments

When reviewing the most fundamental drivers or key needs for investments in Ecological Infrastructure, it can be ascertained that conservation, natural disasters, and socio-economic needs put pressure on various institutions and role-players to enact reasonable measures to protect and maintain Ecological Infrastructure. The prevalence of natural disasters and environmental risks stimulate conservation interest because vulnerable landscapes threaten different assets and economic practices. For example, in South Africa, the frequent occurrence of high intensity and extensive fires, alien plant invasion, and droughts have detrimentally affected natural/ecological assets and economic activities, particularly in the agricultural and forest sector (Forsyth et al. 2010). The systematic review corroborated the recognition of maintaining and restoring Ecological Infrastructure as a sustainable way of abating socio-economic and ecological vulnerabilities and risks (Hansson et al. 2012). Safeguarding a healthy Ecological Infrastructure to tactically address Climate Change related disasters, and Ecosystem-based Adaptation (EbA) measures have become popular approaches in both ecosystems and livelihoods spheres in both developing and developed countries (Nalau et al. 2018). In its healthy condition, Ecological Infrastructure contributes to human livelihood improvement and enhances socio-economic development through Ecosystem Service delivery (MEA 2005). Results showed that drivers of investments in Ecological Infrastructure may be categorised as ‘natural’ and ‘anthropogenic’, and that these drivers require both public and private investment attention. Therefore, maintenance and restoration of Ecological Infrastructure complement land productivity, economic growth, and safeguard food security. Both private and public institutions are anticipated to devise and implement effective ecosystem-based management interventions, ranging from policies to programmes that mitigate Ecological Infrastructure degradation.

## Willingness and desire to invest in Ecological Infrastructure

Although the investment contributions could not be quantified, (because the study’s scope was limited to the systematic literature review, not a meta-analysis of investment capacity), the results

revealed that private landowners are willing to participate and invest in Ecological Infrastructure provided there are compensation measures in place. Financial incentives and funding are generally provided by the government to private landowners who deliver Ecosystem Services by managing Ecological Infrastructure. This analysis, therefore, suggests that incentive-based policies play a pivotal role in encouraging the willingness to participate in EI programmes (Kanchanaroek and Aslam 2018). Beyond awarding economic incentives to attract public and stakeholder participation, there are critical determinants which define possibilities of being a landscape steward or not. Conservation ethics, values and philosophy either encourage or discourage participation and acceptance of the responsibility to restore and maintain Ecological Infrastructure. Where social conditions are favourable, private landowners are more likely to take responsibility for conservation of EI. These conditions include land rights, land ownership and tenure security; access to information in order to awaken conservation interest; bigger farm sizes; higher levels of education and communication and advocacy support from both conservation organisations and government; active neighbourhood networks; private landowner conservation consciousness and interest as well as unique and prominent biophysical environment and features (Franzén et al. 2015; Yeboah et al. 2015; Ma et al. 2018; Welsh et al. 2018; Zhang and Han 2018; Sweikert and Gigliotti 2019). Considering the above determinants, environmental education and awareness campaigns, advocacy, and communication are vital to support conservation interest and willingness to invest. Stakeholder relations and effective community engagements stimulate a willingness to join conservation initiatives. The establishment of economic-based instruments that offer incentives is therefore instrumental in stimulating willingness to invest in EI. However, these must be intertwined with regulatory and law enforcement approaches that seek to protect the EI.

## Institutional support mechanisms and policy regime

The results revealed that diverse investment instruments are executed by either public institutions or through private institutions to manage Ecological Infrastructure in both public and private landscapes. Major institutional investments are financial mechanisms and policy frameworks. Through these investments, conservation programmes and funds are established to achieve conservation goals for Ecological Infrastructure while enhancing economic and social prosperity (Rode et al. 2016). This dual approach is essential amongst developing economies where conservation programmes are anticipated to deliver both ecological and socio-economic deliverables on one budget (Hejnowicz et al. 2014) (However, my results showed a slow uptake of market-based mechanisms in developing nations as compared to developed world, see Figure

2.4). Where 'win-win' solutions are expected, a comprehensive approach is applied to gather different stakeholders to form Public-Private Partnerships (PPP) to mobilise funds from multiple sources (Zhang et al. 2018). PPPs' popularity is growing in the conservation community due to shrinking funding (Glumac et al. 2015; Guillet and Semal 2018) and a desire to strengthen partnerships with the private sector. This investment approach could lead to a long-term collaboration and partnership between the public and private sector, however, prior to formal agreement all partners must have an equal understanding of goals and anticipated outcomes of a partnership to avoid conflict (Glumac et al. 2015). The key potential role-players in these partnerships are envisaged to be communities, government agencies, private landowners or users, private investors, business sector, non-governmental organisations and individual civil society members and other relevant or interested groups. For the South African context, NRM should reinvigorate institutional relations with other national departments that hold a coinciding conservation mandate. These national departments that include (1) Department of Environment, Forestry and Fisheries; (2) Agriculture, Land Reform and Rural Development; (3) Human Settlements, Water and Sanitation (website links in blue) are entrusted with the following conservation responsibilities respectively (1) Ensure healthy and protected environment for the benefit of present and future generations by providing leadership in environmental management, sustainability and conservation; (2) Ensure the protection, rehabilitation, conservation and recovery of depleted and degraded natural resources; (2) Promote sustainable use of natural resources for food security and rural development and (3) Promote efficient and effective management of water resources to ensure sustainable socio-economic development. Concerned departments could commit funds and cooperate in the coordination of institutional arrangements which seek to implement and monitor Ecological Infrastructure restoration and maintenance programmes. Projects such as, Land Care, Adopt-a-River and the 'Working for… programmes' ought to be integrated through planning and prioritisation approaches (DEA and SANBI 2016).

This review showed a shift away from command and control [which emphasises policy compliance (Davis and Gartside 2001)] to economic-based instruments which reward voluntary contributors to Ecosystem Services (ES) maintenance (Boisvert 2015; Hrabanski 2015; Mills et al. 2018). These instruments go beyond compensating private landowners for avoiding practices or operations that potentially damage Ecological Infrastructure. This approach suggests that investments made in the restoration and maintenance of Ecological Infrastructure must be justified, therefore natural resources management programmes should put emphasis on rewarding ecosystem-based management interventions based on ecological outcomes. Programmes such as Agri-Environmental Schemes (Europe), United States Conservation

Reserve Program (United States) and National Market-Based Instruments Pilot Programme (Australia) use a range of different measures and indicators to test ecological outcomes and benefits from EI management (Hajkowicz 2009; Yang et al. 2010). It can be reiterated that Results-Based Programmes (RBP) are more efficient and justifiable than Action-Based Programmes (ABP) and failing to provide evidence will jeopardise possibilities of making the ecological investment case if outcomes are not a priority.

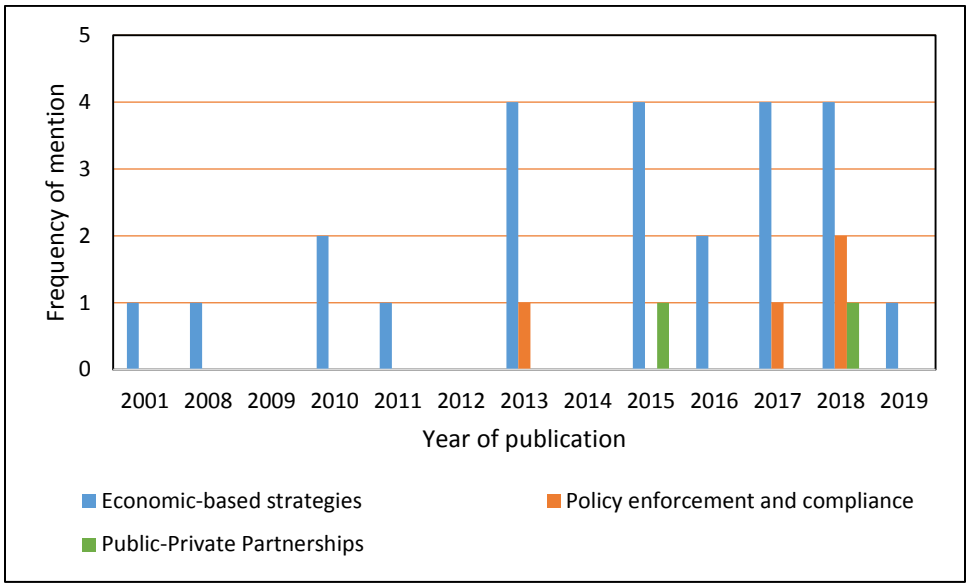



Figure 2.6. Frequency of mention and use of economic-based strategies, policy enforcement, and compliance and public-private partnerships by the literature over the past two decades.

The above description holds an implication for South African NRM programmes. It is imperative for NRM 'working for programmes' (for example Working for Water) to define monitoring measures that demonstrate positive ecological outcomes emanating from the interventions. Anticipated outcomes and monitoring protocols must be clarified accordingly. Dedicated data collectors and data analysts should define indicators and present the information to key and potential stakeholders within and beyond NRM in order to secure their buy-in (Bremer et al. 2016). Intervention viability and precise demonstration of Return on Investment (ROI) could be a convincing and instrumental tool when sourcing finances from the private sector and other vital stakeholders for EI interventions.

## Recommendations and policy implications

Several recommendations were extracted from the review to inform conservation policy and decision makers about available evidence and insights necessary for 'unlocking and securing Ecological Infrastructure investments'. It is important to note that these recommendations may

vary between countries depending on policies and current Ecological Infrastructure maintenance and restoration approaches.

- **Ecological Infrastructure investment funds should be clear on anticipated outcomes and set precise monitoring plan and indicators**. Application of rapidly evolving remote sensing satellite imagery coupled with site inspection could monitor ecological changes (Pagiola et al. 2007). For example, the NRM 'working for... programmes' could consider experimental and monitoring designs to compare areas with ecosystem-based management interventions to areas without. Outcomes will demonstrate whether interventions did achieve the set investment goals or not. Evidence of returns and benefits would attract the interest of investors. Results-driven ecosystem management interventions are widely gaining popularity in the conservation community more than action-driven ecosystem management interventions (Salles et al. 2017; Thompson 2017; Herzon et al. 2018; Sidemo-Holm et al. 2018). Implementers of 'working for… programmes' should have dedicated data collectors and analysts to measure the impact made by the current programmes and they should interpret the indicators for private landowners and other interested stakeholders. The review showed that private landowners' motivation to co-fund is induced by Returns on Investments.
- **Biodiversity Stewardship programmes in the management of Ecological Infrastructure is vital**. Through a holistic landscape conservation approach, a group of landowners could be assigned an ecological landscape to maintain collectively. Payment and incentives could be distributed and shared evenly. The success of this approach relies on local private landowner participation and their vision to achieve success.
- **Strengthen advocacy and communications in order to improve awareness, build capacity and awaken conservation interest**. Clear messaging on Ecological Infrastructure maintenance and restoration benefits is likely to leverage political and social support for investment in Ecological Infrastructure.
- **Formation of Public-Private Partnerships (PPP) could scale up investments**. Mobilised funds could establish risk mitigation support mechanisms to protect businesses, deliver Ecosystem Services and, enhance long term protection of Ecological Infrastructure. Various disciplines and stakeholders (environmental, water sector, insurance companies, corporate institutions, and philanthropists, etc.) need to cooperate and contribute from their experiences and financial resources.
- **South African national departments with overlapping conservation mandates (for example, Department of Environment, Forestry and Fisheries; Human Settlements, Water and Sanitation; Mineral Resources and Energy; Agriculture, Land Reform and**

**Rural Development) should break silos by strengthening conservation engagements and collaborative partnerships** (Angelstam et al. 2017). To facilitate coordination of investments for conservation interventions, these departments should synchronise spatial planning cooperatively and channel resources where there are critical interventions identified.

- **Utilise Community of Practice platforms (e.g. MaReP Forums) where knowledge and learning exchange happen between conservationists, researchers, managers, planners, private sector and funding organisations**. This platform presents a networking opportunity for conservationists and investors and potential funders.

Strategic and effective engagement of key role players is essential to ensure that Ecological Infrastructure maintenance and restoration programmes and policies are holistic and able to achieve conservation goals in integrated landscapes. Well-designed Ecological Infrastructure investment policies could ignite willingness of private landowners and other related partners to invest in EI.

## Conclusion

Demanding development needs drive both governments and private landowners to invest and support improved functionality of Ecological Infrastructure. The drivers for investment in EI are orientated towards improving Ecosystem Services and human-wellbeing. Private landowner participation and engagement is crucial in the management of Ecological Infrastructure. Private landowner willingness to engage and contribute is stimulated by economic and ecological returns. Financial incentives, compensation, and favourable social conditions play a significant role in encouraging private landowners to voluntarily implement interventions and programmes. This review supports and contributes to the evidence-based policy advice by highlighting the measures to instil collaborative partnerships and collective efforts between government and private landowners to maximise investments and expand ecosystem management capacity. Key lessons learnt and recommendations made will help policymakers and conservation managers understand effective institutional support mechanisms that have claimed success in ‘unlocking and securing Ecological Infrastructure investments’. It can be concluded that impactful mechanisms were based on the rewards system and prioritised ecological outcomes resulting from the restoration and maintenance of Ecological Infrastructure. More empirical work dedicated to designing economic-based incentives and finance mechanisms is required as well as the demonstration of key successes and returns on investments in order to make the case for investments.

# Chapter Three: Payments for Ecosystems Services (PES): A review of successes, challenges and failures, and lessons learnt for investments in Ecological Infrastructure.

## Abstract

Payments for Ecosystem Services (PES) have gained global popularity as a new approach of using economic incentives to deliver Ecosystem Services in a sustainable manner. However, there has been insufficient academic literature to advise Ecological Infrastructure investment efforts based on lessons learnt from PES discourse. This study comprises a global Systematic Literature Review of peer-reviewed and grey literature to assess the successes of PES schemes, and failures, and challenges experienced in PES design and implementation. Sixty international studies were reviewed to provide insights for Ecological Infrastructure investment policy advice in South Africa. Results revealed a variety of strong institutional, social, ecological and least economic/financial successes achieved by PES. However, challenges and failures were experienced in different nations depending on institutional arrangements and ecological conditions. To establish a better understanding of more focussed lessons for Ecological Infrastructure investments (using PES model), this study provided policy and investment insights to inform the design, funding, implementation, as well as monitoring and evaluation of PES programmes.

## Introduction

In the past two decades, Payments for Ecosystem Services (PES) have drawn international attention of academia, natural resources practitioners and conservationists as vehicles that promote conservation and address socio-economic challenges (Jespersen and Gallemore 2018). PES were introduced as an economic concept to account for negative ecosystem externalities (Detrimental consequences of economic activities on ecosystem) (Hausknost et al. 2017)[1]. PES are defined as voluntary or market-based approaches which ensure that those who enhance Ecosystem Services (ES) flows are compensated, and beneficiaries (such as users of clean water) of ES bear the costs (Wunder 2005; Cimon-Morin et al. 2013; Martin-Ortega et al. 2013; Diswandi 2017; Smith and Day 2018). Maintenance and restoration of Ecological Infrastructure (a natural or semi-natural functioning ecosystem which delivers services to people) exemplify a conservation intervention to enable ES delivery. The key philosophy of PES is to internalise

[1] It is not my purpose to comprehensively review PES and its criticism but to briefly outline its underpinnings

ecosystem externalities (based on either Coasean[2] or Pigouvian[3] economic theorem) caused by anthropogenic activities and to ascribe a monetary value to ES to help decision-makers realise the rate of ES loss (Martin-Ortega et al. 2013; Bellver-domingo et al. 2016; Chan et al. 2017; Diswandi 2017; Smith and Day 2018). A stimulus for economic approaches to Ecological Infrastructure was achieved through the "Ecosystem Services-human wellbeing" nexus which was popularised by the Millennium Ecosystem Assessment (MEA 2005; Midler et al. 2015; Costanza et al. 2017). The 'Ecosystem Services' metaphor became a vital tool to elevate Ecological Infrastructure understanding onto policy and ecosystem-based intervention management measures (Hausknost et al. 2017). As a result, some governments started intervening through regulation, tax, subsidy or encouragement of payments to private landowners who conserve Ecological Infrastructure (van der Horst 2011; Diswandi 2017).

In 1995, the government of South Africa established a 'Working for Water' programme to protect water resources while empowering previously disadvantaged citizens. Later on, the 'Working for Water' programme broadened its scope and became the Natural Resources Management (NRM) programme to address environmental degradation caused by anthropogenic and natural drivers (e.g. Invasive Alien Plants ) which ultimately disrupt the supply of ES (van Wilgen et al. 2001; Richardson and van Wilgen 2004; Marais and Wannenburgh 2008). The NRM has been cited within the PES discourse because it maintains and restores Ecological Infrastructure whilst alleviating poverty in poor communities through the creation of employment opportunities (Schomers and Matzdorf 2013). NRM investments supplement traditional conservation tactics such as protected areas and national parks because they lack sustainable funding to guarantee continuous management and protection of Ecological Infrastructure (Cimon-Morin et al. 2013). The PES approach initially gained political support in South Africa due to its environmental sustainability and socio-economic development emphasis (Turpie et al. 2007), however, its implementation has faced challenges (Blignaut and van der Elst 2014). For example, the PES approach failed to augment voluntary payments for water services, monitor changes in ES delivery and to secure investments and funds (Turpie et al. 2007).

Despite the international adoption of PES (Carter et al. 2014; Grima et al. 2016), challenges and criticism have also mounted (de Lima et al. 2017; Arriagada et al. 2018). The aim of this chapter was to review the successes, challenges, and failures of implementation of PES as a

[2] No government official is needed, private 'market negotiations' among social actors where ES beneficiary will compensate the ES provider.
[3] Governmental payment programmes through taxing negative or subsidising positive externalities

conservation mechanism in order to extract lessons learnt for Ecological Infrastructure investments. It is anticipated that the insights learnt will improve the understanding of factors that contribute to the successes of PES and other related outcomes (McElwee et al. 2014; Grima et al. 2016; Johnson et al. 2018; Paudyal et al. 2018); provide a clear understanding of challenges and difficulties experienced in the design and implementation of PES schemes (Grima et al. 2016) and help to understand institutional failures that hinder the PES vision (Jespersen and Gallemore 2018).

The following questions were asked:

1. What are the successes of PES schemes in ensuring efficient and effective implementation?
2. What are the challenges and difficulties experienced in PES schemes?
3. What have been the failures of PES schemes?

A systematic review approach was used to contribute to a better understanding of 'unlocking and securing Ecological Infrastructure investments' through comprehensive lessons learnt from PES policy mechanisms. Evidence-based policy advice will inform South African conservation decision makers and practitioners on how to expedite PES programmes as investment tools to support Ecological Infrastructure maintenance and restoration. The PES concept was purposely chosen because of its worldwide acclaimed reputation of offering a win-win governance and policy tool to advance a socio-economic development agenda whilst achieving Ecological Infrastructure restoration and maintenance goals. The PES concept is applicable in Ecological Infrastructure investment dialogue because financial payments and incentives stimulate ecosystem-based management interventions (Farley and Costanza 2010; Hein et al. 2013; Martin-Ortega et al. 2013; Bennett et al. 2014; Rode et al. 2016).

## Methods

Systematic Literature Review (SLR) methodology was selected to access scientific and grey information to achieve the aim of the study and extract lessons essential for evidence-based policy advice for Ecological Infrastructure investments. SLR supports decision-making processes based on evidence in nature conservation (Pullin and Stewart 2007). A Systematic Review Protocol (SRP) was designed to guide the systematic review process (Appendix 3). The SRP set out the strategy of acquiring the literature sources, described the study aim, keywords, questions of the review and described the criteria for inclusion and exclusion of sources. I created a search string consisting of subject and outcomes (Table 3.1) related keywords to extract relevant sources from literature databases (Figure 3.1). I first carried out a pilot search as a test to enhance the search strategy. The search string was widened to ensure a broader coverage of sources suitable

for inclusion (Table 3.2). The search string consisted of synonyms, Boolean logic operators and truncated words. Search words were modified to suit database specifications because some databases (e.g. ScienceDirect, Scopus) do not accept truncated words and wildcards. The search terms excluded Agri-Environmental Schemes (AES) which are interchangeably used as PES (AES investment model was covered in the first data chapter). Relevant literature was sourced from four electronic databases and some studies were opportunistically identified through snowballing sampling to supplement the identification process (particularly for grey literature). ROSES (RepOrting standards for Systematic Evidence Syntheses) workflow was used to screen the identified sources by titles, abstracts, and keywords (Figure 3.1). ROSES was chosen because it is a *pro-forma* and flow diagram created specifically for Systematic Reviews in the conservation sector to present a level of detail and inclusion of rich guidance statements (Haddaway et al. 2018). Relevant studies were reviewed in their entirety. The final sources were imported into ATLAS*.ti* v8.4 for qualitative analysis. Both inductive and deductive coding methods were employed to capture subject information from the primary sources. The key limitation of my methodology is the lack of assurance of inclusivity due to different languages and full-text inaccessibility of some sources.

Table 3.1. Population/Subject, Intervention, Comparisons and Outcomes search elements

| | |
|---|---|
| Population/Subject | All countries, PES programmes in terrestrial and marine ecosystems, peer-reviewed and grey literature. |
| Intervention | Payments for Ecosystem Services: a conservation management intervention used to reach a win-win arrangement between the providers and end-users of ES by compensating ecosystem enhancers and charging the beneficiaries of ES. |
| Comparison | Over a period to track the interest and the uptake of PES mechanisms to improve conservation and achieve sustainability outcomes. |
| Outcomes | Studies measuring the successes, failures, and challenges resulted in the execution of PES programmes. |

Note: This table defines the core focus of search strategy and I used it to qualify and disqualify sources.

Table 3.2. Search strings used to access studies that document successes, challenges, and failures of Payments for Ecosystem Services from electronic databases

| *Assessment of the successes of PES schemes for their ability to ensure efficient and effective environmental governance* | *Review of challenges and difficulties of PES schemes in demonstrating the business case for investments* | *Review of failures of PES schemes based on decisions made by developers* |
|---|---|---|
| "payment* for ecosystem* service*" OR "payment* for environment* service*" OR "payment* for ecol* service*" AND "succe*" OR "achiev*" OR "impact*" OR "effect*" OR "accomplish*" OR "strength*" OR "highlight*" OR "opportunit*" OR "benefit*" OR "positiv*" NOT "Agri-Environmental Schemes" | "payment* for ecosystem* service*" OR "payment* for environment* service*" OR "payment* for ecol* service*" AND "difficult*" OR "challeng*" OR "hind*" OR "barrier*" OR "constrain*" OR "limit*" OR "threat*" NOT "Agri-Environmental Schemes" | "payment* for ecosystem* service*" OR "payment* for environment* service*" OR "payment* for ecol* service*" AND "fail*" OR "risk*" OR "weak*" OR "negative*" NOT "Agri-Environmental Schemes" |

Note: Asterisks* and truncated words were used to retrieve all the different ways those keywords might appear and Boolean logic operators (AND/OR) were used to connect or separate the search terms.

## Results

Despite the exponential growth of PES publications over the past decades (Corbera et al. 2015), this systematic review of peer-reviewed and grey literature has reviewed 60 studies out of 756 studies screened (Figure 3.1). Regardless of fewer publications reviewed than anticipated, the sources yielded evidence to better understand the review questions. The selected studies were compared against the inclusion criteria described in the Systematic Review Protocol (Appendix 3). I deleted 71 duplicates found across databases, and in the end, excluded 625 studies which did not document successes, challenges, and failures of PES as per the exclusion criteria articulated in the Systematic Review Protocol. This exclusion was also based on the PICO model (Table 3.1). Revealed successes, challenges, and failures from all the sources were sorted into major institutional, financial/economic, social and ecological categories (Table 3.3) and lessons learnt are described later in the discussion. The categories showed close linkages that provide an explanation that the factors cannot be easily alienated. Depending on localities, these findings cannot be certainly generalised because successes in certain regions could parallel challenges and failures in other regions. Figures with bars presented frequent words used in the PES literature to describe key concepts found in PES successes, challenges, and failures through the ATLAS.*ti* codes and quotations.

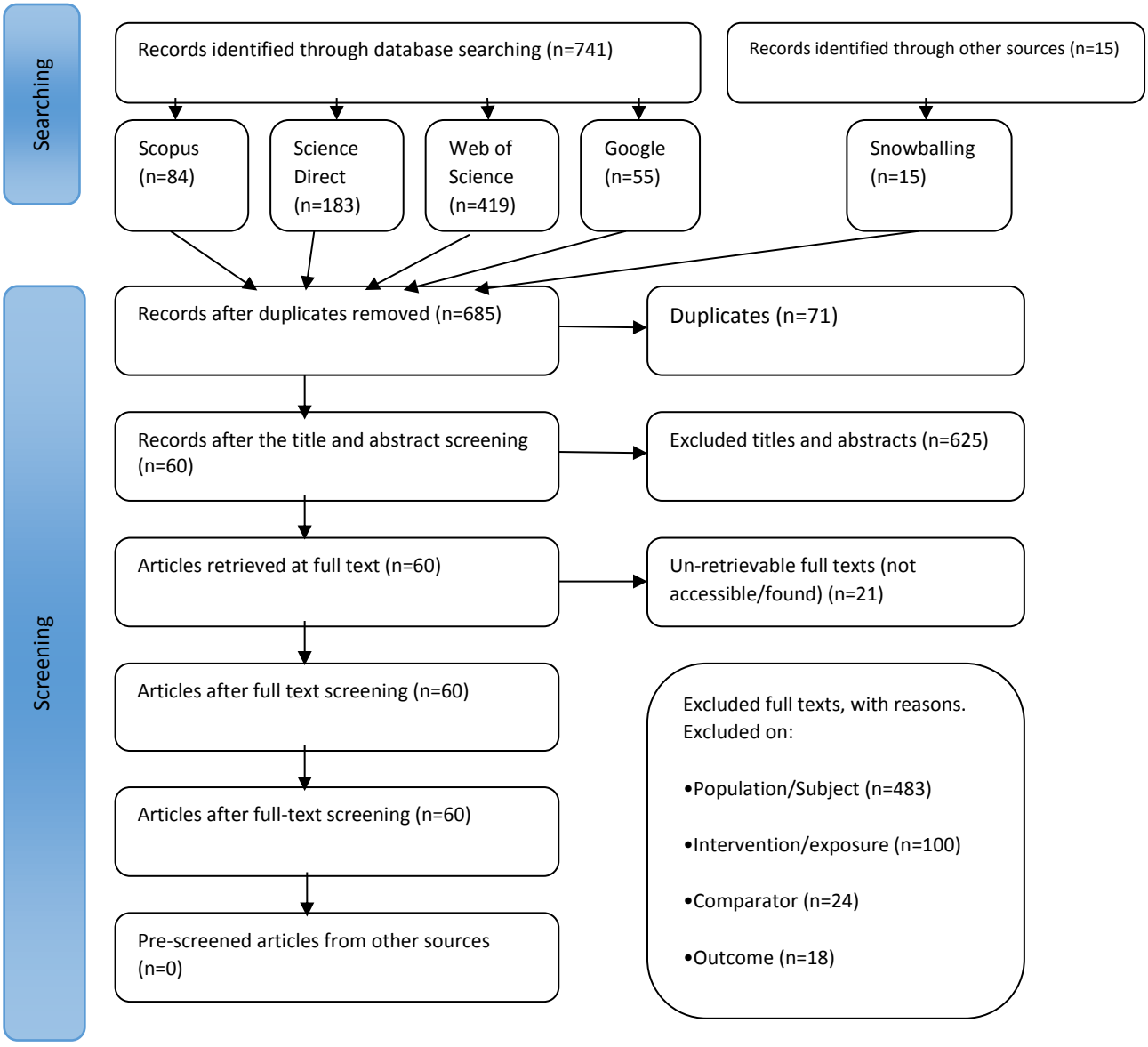



Figure 3.1. ROSES flow diagram for Systematic Reviews used for the screening process of sources from various databases.

Table 3.3. A summarised database of factors that led or contributed to successes and failures of PES and challenges associated with their design and implementation.

| | Institutional | Financial/economic | Social | Ecological |
|---|---|---|---|---|
| PES successes | • Established rapport and trust when setting preconditions for deliberative and iterative contracts<br>• Enabled engagement of intermediary-civil society, government, private sectors to agree on long term contracts, co-benefits, and voluntary agreements<br>• Improved understanding of social, political, economic and institutional contexts to influence socio-cultural values, local Ecosystem Services (ES) and ecological identities<br>• Improved indigenous communities' capacity to gather to address local issues<br>• Public institutions, governmental laws, and property rights empowered local and participating communities to access natural resources<br>• Institutional frameworks influenced role player relationships by enabling funding flows, financial resources distribution, encourage the interest and participation of beneficiaries<br>• Improved scientific understanding of ES | • PES provided conservation finance through incentive-based mechanisms<br>• PES offered public finances to support Green Economy<br>• PES supported ecotourism through revenue generation<br>• PES provided a new source of funding for Ecological Infrastructure protection<br>• Payments assisted to secure land titles | • Improved human livelihoods, participants and their natural livelihoods assets<br>• PES built the capacity of ES providers<br>• PES reduced poverty in rural areas<br>• Communicated ES awareness to communities and improved local perceptions<br>• PES made investments in community-based organisations through community and social projects<br>• Policy incentives influenced and encouraged private landowners to participate in PES | • PES encouraged restoration of Ecological Infrastructure<br>• Enhanced ecosystems and increased the value of biodiversity<br>• Combated deforestation<br>• Provided Climate Change services such as carbon sequestration<br>• Hydrological services: Reduction of sediment loads, improve water quality and quantity in the catchment.<br>• PES monitored ecosystem conditions post PES implementation<br>• PES supported ES delivery: provisioning, regulatory, cultural and support |
| | **Institutional** | **Financial/economic** | **Social** | **Ecological** |
| PES challenges and failures | • Land tenure insecurity and ownership limited long-term benefits and stable production of ES<br>• Land-tenure uncertainty and inappropriate institutional arrangements<br>• Lack of trust in the implementing agent<br>• The commodification of ES became problematic for PES actors and led to unfair situations<br>• Difficulties in the establishment of fair and transparent community-based institutions lead to failure of PES<br>• Failure to offer clear mechanisms to provide institutional safeguards (benefits sharing rules, land rights, legal grievance resolutions)<br>• The slow process of developing legal frameworks, pilot projects, and validation models<br>• Weak rule of law and poor political decisions<br>• Poorly defined land, property and resource rights | • High transaction costs could make the PES inefficient (project design, distribution of funds, monitoring and reporting)<br>• Lack of access to capital for equipment, cost of material, and labour for PES implementation<br>• Too low revenues from Ecosystem Services because of power asymmetries<br>• Logistical challenge: identifying appropriate incentives, and providing additional ES under limited financial resources<br>• Exacerbated existing tensions associated with intensive agricultural production<br>• Inequitable distribution of PES benefits and revenue | • Limited quantitative and empirical data to assess how PES can aid in poverty reduction and under what conditions<br>• Emphasis on PES as a poverty eradication mechanism could lessen conservation and ecosystem restoration ability<br>• Risk of free-riders (a market failure that occurs when some beneficiaries take advantage of ES without contributing to payments)<br>• Social challenges such as equity (access and inclusivity in decision making processes)<br>• Additionality-difficulties in demonstrating the effectiveness of PES over traditional conservation and environmental regulations. i.e. specified baseline)<br>• Lack of inclusivity in participation which creates societal conflicts over land use<br>• Limited benefits to poor people in developing countries<br>• Failure to improve local livelihoods | • Limited demand for service users due to poor understanding of ES supply<br>• Difficulty in ensuring conditionality due to poor monitoring of service provision (making payments on condition that PES interventions generate desired ecological benefits, not upfront)<br>• Poor evaluation of ES delivery<br>• Lack of monitoring and evaluation of impacts of PES schemes to protect ecosystems and improve livelihoods<br>• No environmental and socio-economic baselines for Monitoring and Evaluation of PES performance<br>• Limited provision of ES<br>• Discernible lack of ability to assess the quality and quantity ES enhanced, methodological issues<br>• Low species population and high threats |

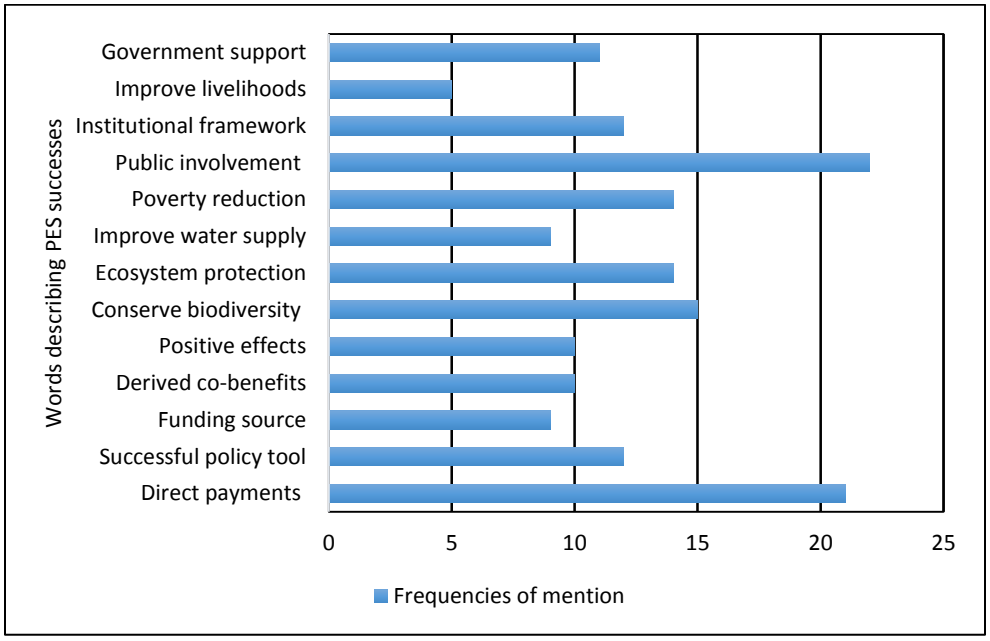



Figure 3.2. A summary of the codes and quotations of PES successes captured via ATLAS *ti*. Bars represent frequency of mention of concepts or phrases describing PES successes.

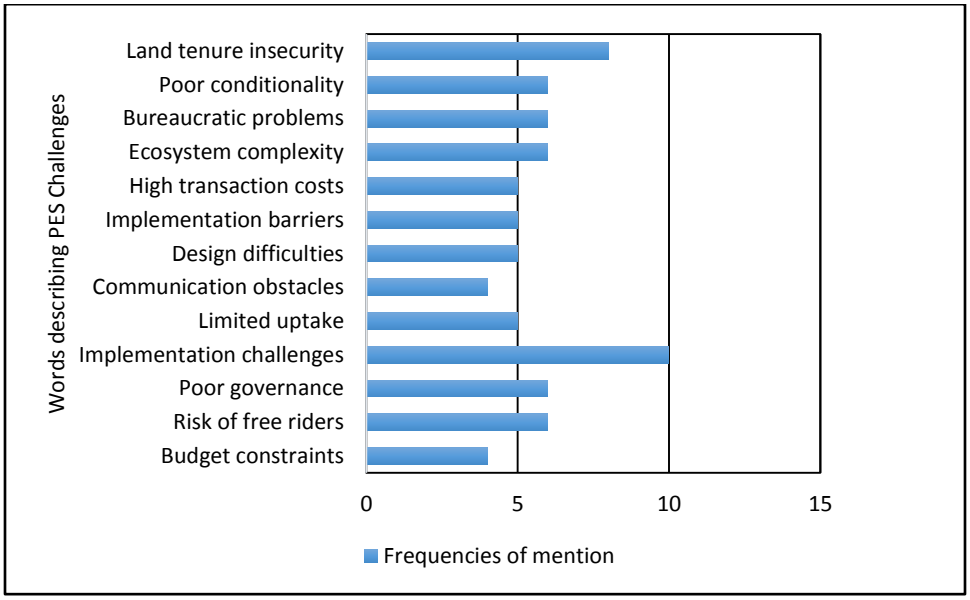



Figure 3.3. A representation of frequency of mention of concepts and phrases used words to describe PES challenges. These were generated by an automated word extraction process on ATLAS *ti*.

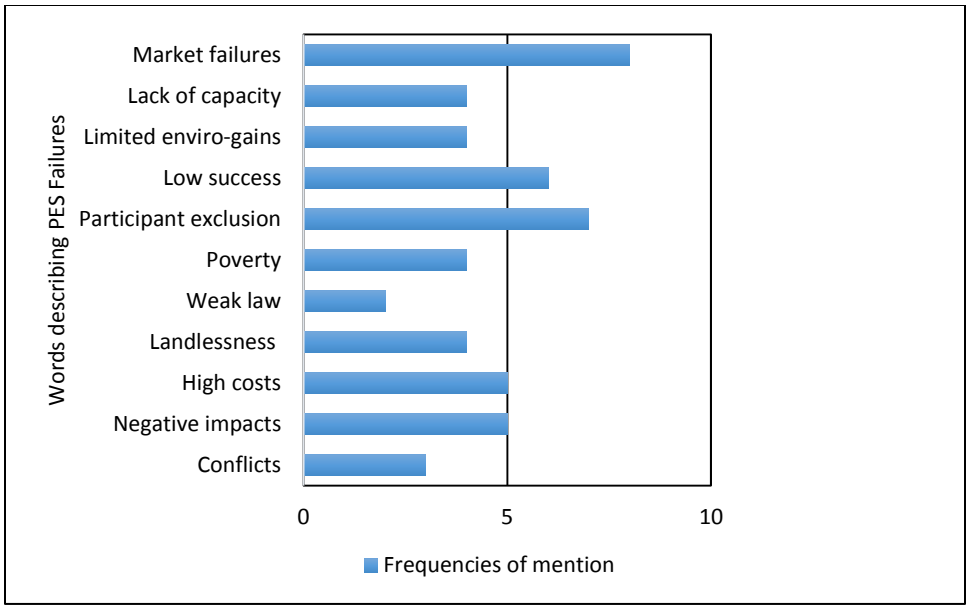



Figure 3.4. A summary of the codes and quotations of PES captured via ATLAS *ti*. Blue bars represent frequency of mention of concepts or phrases describing PES failures.

## Discussion

The successes, challenges and failures arising from PES have not received sufficient academic attention (Duong and de Groot 2018), while a large body of scientific literature tends to focus on ideal PES models (Jespersen and Gallemore 2018). This did not come as a huge surprise in the systematic review of PES studies because the following authors reviewed no more than 50 studies: Bremer et al. (2018) systematically reviewed 50 studies; Blundo-Canto et al. (2018) systematically reviewed 46 studies; Jespersen and Gallemore (2018) systematically reviewed 44 studies; and Corbera et al. (2015) systematically reviewed 34 studies. The dearth of comprehensive studies on effectiveness of PES could be regarded as a significant blind spot in the literature of Ecological Infrastructure investments as a whole (Jespersen and Gallemore 2018). Sufficient literature is essential to understand the role of PES as an investment tool to support conservation interventions through development of more robust policy mechanisms (Jespersen and Gallemore 2018; Jones et al. 2019).

PES programmes were commonly designed to achieve both livelihood upliftment and conservation outcomes. Their successes were subject to institutional frameworks, policies, socio-economic and ecological outcomes and cooperative partnerships between private and public institutions. Institutional frameworks stimulated role-players to participate and access various benefits resulting from PES programmes (Pham et al. 2015; Grima et al. 2016). PES are capable of generating funding for conservation agencies, initiatives, ecotourism, and green economy, therefore it is feasible to secure long-term finance through PES (To and Dressler 2019). However, PES funding mechanisms may not be considered as an entire replacement of traditional funding mechanisms offered by national or state programmes (Schirpke et al. 2018). They are supplementary funding instruments intended to provide localised socio-ecological and economic co-benefits that improve community livelihoods while enhancing the ecological landscape. PES have succeeded in improving indigenous communities and rural groups by providing socio-economic contributions such as human capacity development to manage local Community-Based Organizations (CBO) (Carter et al. 2014). Community empowerment to manage natural resources and Ecological Infrastructure is important in developing countries where conservation is anticipated to address both social and ecological vulnerabilities (McElwee et al. 2014).

Ecological successes revealed that PES programmes enhance Ecological Infrastructure and ecosystem conditions. For example, reforestation interventions to tackle Climate Change were shared by the global community as a good example of carbon sequestration ES. Another

example was the improvement of hydrological services in catchments to mitigate water scarcity, where water quality and quantity were augmented. PES strengthened water security efforts under the detrimental conditions of degraded Ecological Infrastructure and Climate Change. The successes of PES as a Market-Based Conservation Instrument (MBCI) provide relevant and valuable lessons for a South African Ecological Infrastructure investment desire to accrue conservation management and socio-economic funding. PES success relies on and requires a commitment of long-term funds, therefore timeframes and operating projects linked to PES should be in the region of 10-30 years (Martin-Ortega et al. 2013).

Despite the successful implementation of PES, challenges were also encountered in various countries across the world. Land tenure insecurity and high transaction costs remain the most challenging institutional barriers in PES design and implementation (Johnson et al. 2018), and these barriers are of particular concern in a South African context where issues of land reform (rightly or wrongly) and financial constraints are prevalent (Turpie 2004). Land ownership is currently viewed as a contentious political issue and the ownership insecurity could threaten the possibilities and willingness of private landowners to invest in Ecological Infrastructure restoration and maintenance on the private properties. Ideally, the South African government ought to facilitate trust building sessions through public engagement in order to address land tenure regimes in both rural and urban landscapes (Johnson et al. 2018). Some studies have shown that land ownership and institutional arrangements hinder effective implementation of PES programmes in developing countries (Clements et al. 2010; Johnson et al. 2018).

These challenges discourage participant involvement and contribution to the functioning of PES programmes. The aforementioned challenges generally emanate from the closed and opaque establishment of Community-Based Organisations (CBOs) or agencies entrusted with the PES design and implementation. Exclusion of relevant role players and potential stakeholders incites social conflicts and detrimentally impacts the PES design. Poorly designed PES programmes translate into dysfunctional operations which are full of logistical and administrative discrepancies, such as a dearth of monitoring and evaluation of ES delivered and livelihoods enhanced (Borner et al, 2017). PES further become susceptible to the risk of free-riders and the demonstration of a business case for Ecological Infrastructure investments fails as a result of poor design (Lau 2013; Bennett et al. 2014). Conservation agencies or countries intending to establish PES programmes ought to be inclusive and open to interested and affected stakeholders. The benefit of inclusivity is to capitalise on diverse knowledge and capacity brought by different role players into preparation for unforeseen technical, administrative and functionality challenges.

Failing to engage the public leads to poor clarification of benefit sharing rules, persistent poverty in developing countries and social challenges and conflicts at ground level (Kumar et al. 2014).

PES design and operation received criticism for various failures and problems worldwide. Failing to formulate clear and appropriate institutional frameworks weakens the reputation of PES. A common noticeable failure is conditionality criteria, for example PES that lack a Monitoring and Evaluation (M&E) framework and baseline indicators to measure and assess benefits derived from conservation management interventions. In the absence of baseline indicators, payments are made in advance in good faith that anticipated Ecosystem Services will be delivered, and this is a risk to these projects. Setting-up PES programmes require significant budgets and failing to demonstrate positive impact may lead to complete failure (Sommerville et al. 2011).

## Policy implications and lessons for Ecological Infrastructure investments

To inform Natural Resources Management practitioners, policymakers and other key stakeholders in the Ecosystem Services fraternity, below are lessons and insights to consider when designing, implementing and evaluating PES with better chances of success.

### Design

- PES programmes ought to be designed through an inclusive and consultative process to enable transparent and participatory decision-making processes. Community members and stakeholders are envisaged to set up regulations, decide how to manage PES payments and budgets, resolve internal issues and address social equity (Hayes and Murtinho 2018; Paudyal et al. 2018).
- When designing the PES, practitioners ought to invest time and seek to understand complications, complexities and identify institutional barriers (administrative, political and legal) to be experienced during execution. The foreseeable barriers are land tenure arrangements, transaction costs, payment structure and government policy including social, ecological, financial or economic and institutional arrangements (Reed et al. 2014; de Lima et al. 2017; Hayes and Murtinho 2018; Paudyal et al. 2018).

### Funding

- Operating PES requires substantial financial resources. Funds could be sourced from both private and public sector institutions. Public funding can be raised through the following legal instruments: penalties, taxes, bank loans, biodiversity offset and environmental funds. Private

funding can be secured through Non-Governmental Organisations, Non-Profit Organisations, charities, foundations, local or international private investments and businesses (Sattler et al. 2013; Jones et al. 2019).

- Development of alternative and additional funding streams is essential as well as stimulation of voluntary participation (Hein et al. 2013; Liu and Kontoleon 2018).

**Implementation and, Monitoring and Evaluation**

- Clear Monitoring and Evaluation (M&E) frameworks must identify and explain the indicators to be used. For example, assessment of species, threats, trends or differences made by conservation interventions and how they will be monitored. The M&E exercise can absorb a substantial amount of PES budget (9-19%), therefore dedicated funding to evaluate is essential to build evidence and make a business case for investments (Sommerville et al. 2011; Pham et al. 2015).
- A functional monitoring system helps implementers and partners to communicate the results to the funders and attract new potential investors/funders while supporting the growth of conservation interventions (de Lima et al. 2017).
- Uncertainties (institutional, social, economic/financial and ecological) must be explicitly addressed to understand the potential measures to progress, cope and adapt to unexpected events and guarantee long term viability of PES schemes. (Consideration of possible uncertainties due to political interests is crucial).

## NRM as a PES: implication for policy advice

The South African NRM programme is regarded as a PES because Ecological Infrastructure functions and biodiversity of catchments are targeted. The NRM programme does not fully reward private landowners for Ecological Infrastructure maintenance and restoration, however, it employs locals to clear invasive alien vegetation, and to restore fire regimes in both public and private ecological landscape through government investments. The NRM is not regarded as an economic mechanism to internalise externalities by commodifying Ecosystem Services; in this case government pays for conservation interventions to deliver ES (Schomers and Matzdorf 2013). The following countries have utilised PES policy mechanisms and financial incentives programmes:

The **Chinese** government subsidises private landowners for retiring the land and restoring degraded landscape. This programme improves the natural environment and alleviates poverty (Liu et al. 2019).

The **United States** use a Land Retirement approach through agri-environmental policy which offers monetary compensation for a period of time ranging from 10-15 years to improve soil, wildlife, air and water quantity and quality and other conservation interventions (Liu et al. 2019).

In **Europe**-the PES mechanism internalises negative ecosystem externalities. Common Agricultural Policy (CAP) requires EU state members to offer payments to private landowners who voluntarily implement conservation management interventions to enhance ecological landscapes (de Krom 2017; Nielsen et al. 2018). However, this approach has sparked a discussion on whether payments are offered based on ecological outcomes or based on actions implemented? (Arnott et al. 2019).

In **Costa Rica**-the PES was founded in 1996 based on a political support system. It intends to deliver these services: biodiversity conservation, augmentation of water services, aesthetic beauty of nature and mitigation of greenhouse gases (Fletcher and Breitling 2012). Private landowners are rewarded for reforestation or conserving the forest with the intention of integrating conservation considerations in natural landscapes that fall outside protected areas (Pagiola 2006).

In **Mexico**-the PES was established in 2003 to halt over-utilisation of aquifers. The PES is financed through compulsory water taxes. Private landowners are incentivised for conserving forest ecosystems (Corbera et al. 2008; Russi et al. 2016).

The vast majority of PES programmes (China, Mexico, Costa Rica and the Agri-Environmental Schemes in Europe and the United States) are driven by states under national policy frameworks. Funds are accumulated through taxes and the level of payments are politically regulated and established (Gómez-baggethun and Muradian 2015). To date, 90% of PES funds come from governments and 99% of PES programmes focus on public goods (Gómez-baggethun and Muradian 2015; Vatn 2018). Institutional and policy frameworks, incentives and economic-based instruments are considered as effective and efficient PES financing mechanisms (Sumaila et al. 2017). Optimising synergies across sectoral policies is a major resource mobilisation approach to help identify co-funding possibilities and secure funding to support PES (Sumaila et al. 2017). To contribute to the PES funding in low-income and middle countries, these funding mechanisms are recommended (1) ecotourism levies through visitors' contribution in protected areas (2) water taxes for hydrological services (3) compensation of developing countries for conserving forests and sequestering carbon through the Reduced Emissions from Degradation and Deforestation

(REDD) mechanism (4) green commodities trading where private businesses indicate that their products and processes hold green standards regarding the environment, health and social component (Vatn 2018) and (5) biodiversity markets where conservation funds or conservation banking schemes sell biodiversity credits and utilise biodiversity offset funds (compensatory mechanism for loss of biodiversity due to developmental activity) (Hein et al. 2013; Vatn 2018).

## Conclusion

The findings of this study advance the knowledge of institutional, social, economic/financial and ecological factors that affect the design and implementation of PES based on synthesised successes, challenges, and failures of PES programmes. Successes and failures vary in different countries, and what succeeded in one country could result in failure in another country, depending on institutional, social, economic/financial arrangements and ecological conditions. Despite this, acquiring a global understanding of documented successes, challenges and failures of PES programmes helps decision and policy-makers, managing authorities and practitioners learn appropriate PES design and policy frameworks based on practices and experiences. Well-designed PES programmes effectively deliver Ecosystem Services and socio-economic benefits whilst poorly designed ones could result in wasteful expenditure and sources of conflict (Borner et al. 2017). To support PES design, guidelines and principles must be developed to address the highlighted institutional, social, economic/financial and ecological challenges and failures. The following features could lessen undesired failures and maximise possibilities of successes: (1) a participatory and inclusive design and implementation of PES which cautiously considers why and how stakeholders and partners participate to ensure equity (2) an application of an integrated monitoring and evaluation system is vital to understand key social, economic and ecological effects and benefits of PES, (3) even though PES are a funding mechanism for biodiversity conservation, they may not be anticipated to fill the gap between funds generated and funds required (Hein et al. 2013), it is essential to devise funding strategies to ensure PES sustainability.

# Chapter Four: Conclusion and Recommendations

This chapter presents a concluding narrative and qualitative synthesis of the systematic literature review and further recommends measures to scale up Ecological Infrastructure investments through policy advice.

The thesis aimed to improve the understanding of 'unlocking and securing Ecological Infrastructure investments' by reviewing viable investment mechanisms applied in other countries. Acquiring a better understanding of investments in EI supports the long-term plans to establish Ecological Infrastructure investment and funding pipelines to close the current funding gap in DEFF Natural Resources Management and conservation sector in South Africa as a whole. Systematic Literature Review research methodology was employed to ensure rigour, objective, transparent review (Collaboration for Environmental Evidence 2013) and to produce comprehensive and reproducible reviews of evidence and lessons (Bilotta et al. 2014). Relevant lessons, evidence, and insights from Ecological Infrastructure investment and financing models (AES, PES) were presented to guide and inform natural resources managers, policy and decision-makers who seek to maintain and restore Ecological Infrastructure for the benefit of reducing ecological degradation, meeting sustainability goals and curbing business risk through policy development.

The study results showed different (but related) developmental and conservation drivers that stimulate the need to invest in Ecological Infrastructure. These needs were both natural and anthropogenic in nature. They included Climate Change; Water management; Biodiversity protection and Ecosystem Services; Mitigation of agricultural impacts and Agronomic development. Conserving and maintaining Ecological Infrastructure is essential to ensure both ecological and socio-economic benefits. These benefits include both Ecosystem Services delivery and improvement of livelihoods. It is crucial to engage and involve private landowners, government authorities, business sector, potential investors and various disciplines (e.g. political leaders, financial institutions, built engineering sector etc.) when seeking investments through partnerships.

The investment capacity and willingness of private landowners to participate in EI maintenance and restoration is influenced and shaped by incentives and compensatory measures. Socio-economic characteristics and distinctive environmental features further stimulate landowner interest to maintain and restore Ecological Infrastructure. Therefore, rewarding economic returns and conservation benefits prompt investment interest. However, maximising private investments

to support EI conservation and management measures remains a priority. Intensified efforts to promote conservation awareness and EI importance are beneficial to stimulate investment willingness and dedicated efforts to EI restoration and maintenance (García-Llorente et al. 2011).

## Policy regime and institutional support mechanisms

Different policy tools and institutional support mechanisms have become instrumental when encouraging private landowners and stakeholders to collaborate and explore investments to support Ecological Infrastructure conservation programmes. In European countries, the Common Agricultural Policy (CAP) was formulated to provide Ecosystem Services from farmlands and forestry sectors while optimising environmental sustainability. The CAP required all member states, in conjunction with private landowners to implement Agri-Environmental Schemes (AES) to counteract biodiversity and ecosystem degradation (Russi et al. 2016; Zimmermann and Britz 2016; de Krom 2017). This case exemplifies the use of policy and cooperation support mechanisms to initiate partnership amongst stakeholders to address Ecological Infrastructure conservation needs. Lessons learnt from the AES model showed that the programme generates substantial investments, improves Ecological Infrastructure condition and utilises incentives to encourage private landowner participation. However, AES have not used evidence of ecological outcomes to reward participants. Latest insights suggest that AES should make payments to farmers based on the positive ecological impacts generated, not merely compliance with set rules and actions made (Russi et al. 2016). This approach requires clear monitoring and evaluation methods to prove the effectiveness of conservation interventions (Chapter 2).

## Public policies and cooperation

Public policies were effective and impactful mechanisms to ensure positive net conservation benefits. These regulatory measures ensured that private landowners and business sector adopt sensible means to manage Ecological Infrastructure. Policies further required institutions to improve ecological conditions on their sites, particularly when their practices degraded or reduced Ecological Infrastructure quality. Policy tools also created a link between conservation organisations and corporate players to support conservation management interventions, through investments. ‘Unlocking and securing Ecological Infrastructure investments’ require improved collaboration between finance and conservation sector. This approach requires facilitated dialogue and investment planning across conservation related institutions (Chapter 2).

## Market-Based Conservation Instruments

The South African NRM programme was established to provide seed funding for Ecological Infrastructure maintenance and restoration across the country. Application of economic-based policy mechanisms that use incentives and compensation for Ecosystem Services supply are gaining traction globally more than 'command and control regulations' that impose directives (Davis and Gartside 2001; Gómez-baggethun and Muradian 2015; Mills et al. 2018). Incentives and compensation should be provided by public and private organisations to implementers of ecological restoration and maintanance based on ecological outcomes delivered (Chapter 2).

## Payments for Ecosystem Services (PES)

PES programmes are globally becoming eye-catching mechanisms to address negative ecosystem externalities due to resource extraction whilst aiming to enhance social and economic conditions (Kolinjivadi et al. 2014). PES programmes promoted ecological restoration and ecosystem services delivery, whilst they have attempted to alleviate poverty in developing countries (Carter et al. 2014). PES have made better progress in delivering ES, alleviating poverty through meaningful economic contributions and generating revenue for Ecological Infrastructure protection. However, there were challenges and failures that hindered their success such as high transaction costs, weak institutions, poor management capacity, and land insecurity (Chapter 3). Practical measures to improve their performance are summarised in Table 4.1. The review of PES successes, failures and challenges revealed valuable insights and lessons for South African Ecological Infrastructure investment journey and possibly for other institutions who seek to employ a PES as an Ecological Infrastructure Investment tool.

Table 4.1. Summary of significant lessons learnt from the Systematic Literature Reviews of both research chapters.

| Ecological Infrastructure investment lessons learnt from chapter two | Ecological Infrastructure investment lessons learnt from chapter three |
|---|---|
| Government is generally anticipated to play a leading role in coordinating Ecological Infrastructure investments through policy development and political support.<br><br>**Agri-Environment Scheme**<br>Agri-Environmental Schemes are beginning to offer financial rewards based on the ecological outcomes delivered (enhancement and conservation of Ecological Infrastructure), rather than conservation management interventions. The success of this investment approach relies on the definition of key indicators to determine anticipated results (Schroeder et al. 2013; de Krom 2017)<br><br>**Public-Private Partnership**<br>Public-Private Partnerships help to raise and mobilise funding from multiple sources for conservation and maintenance of Ecological Infrastructure (Glumac et al. 2015; Zhang et al. 2018).<br><br>**Public Policy and Market-Based Conservation Instruments**<br>The public policy requires that the government offer incentives to private landowners who protect Ecological Infrastructure and supply Ecosystem Services (Duke et al. 2013). Government ought to pay closer attention to incentivisation and compensation because contemporary policy-making strategies are shifting away from traditional command and control measures which enforce directives for non-compliance to laws and policies that encourage private landowners to contribute to maintenance and conservation of Ecological Infrastructure. The South African government should develop ecological compensation and incentivisation policies (Davis and Gartside 2001).<br><br>The above recommendations would be achievable through effective collaboration amongst government bodies, non-governmental agencies, corporate and private sectors and private landowners (Franks and Emery 2013). | These lessons and insights are essential for the design, implementation, and evaluation of PES. However, there is no one-size-fits-all arrangement for the success of PES programmes, but specific thoughts are necessary to be considered for effectiveness in PES implementation.<br><br>**Design**<br>PES designers and affected parties should gather through a consultative arrangement to unpack and understand regulations governing PES, payments, discuss possible internal conflicts, budget and other related matters (Paudyal et al. 2018). Recognise and address administrative and organisational needs. Communities should be supported to manage PES in a manner that enables the flow of anticipated results (Hayes and Murtinho 2018). Furthermore, there must be a grievance mechanism to promote accountability and transparency in the revenue sharing amongst the locals (Sommerville et al. 2011) and PES programmes should be designed in a manner which maximises social, economic and ecological benefits.<br><br>**Implementation**<br>There is no one-size-fits-all approach for efficient implementation of PES (Kemkes et al. 2010). However, the implementation of PES requires locally developed efficient and transparent management systems to enable a fair distribution of community benefits amongst participating communities (Reed et al. 2014). It is ought to be based on these key elements: (i) collection and utilisation of baseline data to provide evidence of effectiveness delivery of ecosystem services (ii) cognisance of dynamic nature of ecosystems and (iii) inclusion of risk metrics such as climate change and invasive species (Borner et al. 2017).<br><br>**Monitoring and Evaluation**<br>PES programmes must have a framework to monitor and evaluate conservation and ecosystem services delivery. Indicators must be developed (i.e. positive results, threats, species, etc.), a plan to monitor, (i.e. using remote-sensed or ground-based data to track changes over time) and how the information will be used to inform payments and secure buy-in from potential investors (Sommerville et al. 2011).<br><br>**Funding**<br>PES are vital to generate new funding for Ecological Infrastructure and they have a potential to lead to long-term funding, however, they cannot be anticipated to substitute traditional funding mechanisms (Hein et al. 2013). Funds to support PES can be sourced from private and public institutions. These measures can be used to solicit public funds, public budget, environmental taxes, fines and businesses, Non-Governmental Organisations can also inject funds to support PES programmes (Sattler et al. 2013). |

Note: **The aim of the review is to inform policy and decision makers and NRM practitioners about Ecological Infrastructure investment models, both AES and PES. These are considered as recommendations and measures to be executed in attempts to grow investments and develop financial mechanisms through government and private sector support.**

# Conclusion

Investments in Ecological Infrastructure require collaborative and multidisciplinary approaches across organisational boundaries where different state and private organs contribute financial resources and intellectual capacity. The systematic literature reviews presented in this thesis demonstrated how market-based conservation mechanisms have been used to promote Ecological Infrastructure investments elsewhere. Private landowners and business sector involvement would play an integral role in making investment instruments function effectively. I recommend development of an Ecological Infrastructure investments policy based on lessons and insights I have presented from Public-Private Partnerships, Agri-Environmental Schemes, Public Policies, Market-Based Conservation Instruments and Payments for Ecosystem Services. Additionally, this research contributes to the policy design literature by highlighting the drivers and needs for Ecological Infrastructure investments as well as the factors that stimulate private landowner willingness to invest in Ecological Infrastructure. This understanding helps to coordinate collaborative efforts and collective responsibility to share funding burden between private and public institutions. Most of the solutions described above need government and private sector attention because government is meant to create a conducive environment for investments. A framework to generate investment pipeline should be developed. There is also a need to review and explore more investment models as well as other specific policy tools which support finance and funding investments.

### Implications for future research

Grey areas warranting further research were also identified. Further research should scrutinise funding and finance mechanisms to help build an Ecological Infrastructure investment framework for South Africa. Furthermore, there is a need to broaden the understanding of funding tools such as Conservation Funds (biodiversity banks and Green Bonds) and long-term public and private partnerships. Improved understanding will help policymakers and decision-makers to understand how to design economic-based policies that support and promote collaborative management.

## References

Angelstam P, Barnes G, Elbakidze M, et al (2017) Collaborative learning to unlock investments for functional ecological infrastructure: Bridging barriers in social-ecological systems in South Africa. Ecosystem Services 27:291–304. doi: 10.1016/j.ecoser.2017.04.012

Arnott D, Chadwick D, Harris I, et al (2019) What can management option uptake tell us about ecosystem services delivery through agri-environment schemes? Land Use Policy 81:194–208. doi: 10.1016/j.landusepol.2018.10.039

Arponen A, Heikkinen RK, Paloniemi R, et al (2013) Improving conservation planning for semi-natural grasslands: Integrating connectivity into agri-environment schemes. Biological Conservation 160:234–241. doi: 10.1016/j.biocon.2013.01.018

Arriagada R, Villaseñor A, Rubiano E, et al (2018) Analysing the impacts of PES programmes beyond economic rationale: Perceptions of ecosystem services provision associated to the Mexican case. Ecosystem Services 29:116–127. doi: 10.1016/j.ecoser.2017.12.007

Batáry P, Dicks L V., Kleijn D, Sutherland WJ (2015) The role of agri-environment schemes in conservation and environmental management. Conservation Biology 29:1006–1016. doi: 10.1111/cobi.12536

Bayliss HR, Haddaway NR, Eales J, et al (2016) Updating and amending systematic reviews and systematic maps in environmental management. Environmental Evidence 5:0–7. doi: 10.1186/s13750-016-0073-8

Bellver-domingo A, Hernández-sancho F, Molinos-senante M (2016) A review of Payment for Ecosystem Services for the economic internalization of environmental externalities: A water perspective. Geoforum 70:115–118. doi: 10.1016/j.geoforum.2016.02.018

Bennett DE, Gosnell H, Lurie S, Duncan S (2014) Utility engagement with payments for watershed services in the United States. Ecosystem Services 8:56–64. doi: 10.1016/j.ecoser.2014.02.001

Bennett G, Cassin J, Carroll N (2016) Natural infrastructure investment and implications for the nexus: A global overview. Ecosystem Services 17:293–297. doi: 10.1016/j.ecoser.2015.05.006

Bilotta GS, Milner AM, Boyd I (2014) On the use of systematic reviews to inform environmental policies. Environmental Science and Policy 42:67–77. doi: 10.1016/j.envsci.2014.05.010

Bishop J, Kapila S, Hicks F, et al (2009) New Business Models for Biodiversity Conservation. Sustainable Forestry 28:285–303. doi: 10.1080/10549810902791481

Blignaut J, Aronson J (2008) Getting serious about maintaining biodiversity. Conservation Letters 1:12–17. doi: 10.1111/j.1755-263X.2008.00006.x

Blignaut J, Marais C, Turpie J (2007) Determining a charge for the clearing of invasive alien plant species (IAPs) to augment water supply in South Africa. Water South Africa 33:27–34

Blignaut JN, van der Elst L (2014) Restoration of natural capital: Mobilising private sector investment. Development Southern Africa 37–41. doi: 10.1080/0376835X.2014.933699

Blundo-Canto G, Bax V, Quintero M, et al (2018) The Different Dimensions of Livelihood Impacts of Payments for Environmental Services (PES) Schemes: A Systematic Review. Ecological Economics 149:160–183. doi: 10.1016/j.ecolecon.2018.03.011

Boisvert V (2015) Conservation banking mechanisms and the economization of nature: An institutional analysis. Ecosystem Services 15:134–142. doi: 10.1016/j.ecoser.2015.02.004

Borner J, Baylis K, Corbera E, et al (2017) The Effectiveness of Payments for Environmental Services. World Development 96:359–374. doi: 10.1016/j.worlddev.2017.03.020

Bos M, Pressey RL, Stoeckl N (2015) Marine conservation finance: The need for and scope of an emerging field. Ocean and Coastal Management 114:116–128. doi: 10.1016/j.ocecoaman.2015.06.021

Bremer LL, Auerbach DA, Goldstein JH, et al (2016) One size does not fit all: Natural infrastructure investments within the Latin American Water Funds Partnership. Ecosystem Services 17:217–236. doi: 10.1016/j.ecoser.2015.12.006

Bremer LL, Brauman KA, Nelson S, et al (2018) Relational values in evaluations of upstream social outcomes of watershed Payment for Ecosystem Services: a review. Current Opinion in Environmental Sustainability 1–8. doi: 10.1016/j.cosust.2018.10.024

Browder G, Ozment S, Bescos IR, et al (2019) Integrating Green and Gray: Creating Next Generation Infrastructure

Carter J, Wilkie D, Clements T, et al (2014) Evidence of Payments for Ecosystem Services as a mechanism for supporting biodiversity conservation and rural livelihoods. Ecosystem Services 7:10–21. doi: 10.1016/j.ecoser.2013.12.003

CEBC 2006 (2006) Guidelines for Systematic Review in Conservation and Environmental Management.

Chan KMA, Anderson E, Chapman M, et al (2017) Payments for Ecosystem Services: Rife With Problems and Potential—For Transformation Towards Sustainability. Ecological Economics 140:110–122. doi: 10.1016/j.ecolecon.2017.04.029

Cimon-Morin JÔ, Darveau M, Poulin M (2013) Fostering synergies between ecosystem services and biodiversity in conservation planning: A review. Biological Conservation 166:144–154. doi: 10.1016/j.biocon.2013.06.023

Clark R, Reed J, Sunderland T (2018) Bridging funding gaps for climate and sustainable development: Pitfalls, progress and potential of private finance. Land Use Policy 71:335–346. doi: 10.1016/j.landusepol.2017.12.013

Clements T, John A, Nielsen K, et al (2010) Payments for biodiversity conservation in the context of weak institutions: Comparison of three programs from Cambodia. Ecological Economics 69:1283–1291

Collaboration for Environmental Evidence 2013 (2013) Guidelines for Systematic Reviews in Environmental Management

Constitution of the Republic of South Africa 1996 (1996) Constitution of the Republic of South Africa, 1996

Cooke A, Smith D, Booth A (2012) Beyond PICO: The SPIDER Tool for Qualitative Evidence Synthesis. Qualitative Health Research 22:. doi: 10.1177/1049732312452938

Coralie C, Guillaume O, Claude N (2015) Tracking the origins and development of biodiversity offsetting in academic research and its implications for conservation: A review. Biological Conservation 192:492–503. doi: 10.1016/j.biocon.2015.08.036

Corbera E, Martin A, Fisher J (2015) Payments for ecosystem services in the tropics: a closer look at effectiveness and equity. Current Opinion in Environmental Sustainability 14:150–162. doi: 10.1016/j.cosust.2015.06.001

Corbera E, Soberanis GC, Brown K (2008) Institutional dimensions of Payments for Ecosystem Services: An analysis of Mexico' s carbon forestry programme. Ecological Economics 68:743–761. doi: 10.1016/j.ecolecon.2008.06.008

Costanza R, Cumberland J, Daly H, et al (1997) An Introduction to Ecological Economics. St. Lucie Press and ISEE, Florida 33431

Costanza R, de Groot R, Braat L, et al (2017) Twenty years of ecosystem services: How far have we come and how far do we still need to go? Ecosystem Services 28:1–16. doi: 10.1016/j.ecoser.2017.09.008

Costanza R, Groot R De, Sutton P, et al (2014) Changes in the global value of ecosystem services. Global Environmental Change 26:152–158. doi: 10.1016/j.gloenvcha.2014.04.002

Costanza R, Kubiszewski I, Ervin D, et al (2011) Valuing ecological systems and services. Biology Reports 6:1–6. doi: 10.3410/B3-14

Crafford J, Hassan R (2014) Relationships between ecological infrastructure and the economy: The case of a fishery. South African Journal of Science 110:1–8

Cullis J, Görgens A, Marais C (2007) A strategic study of the impact of invasive alien plants in the high rainfall catchments and riparian zones of South Africa on total surface water yield. Water South Africa 33:35–42

Cumming T (2013) Principles for Investing in Ecological Infrastructure

Cumming TL, Shackleton RT, Förster J, et al (2017) Achieving the national development agenda and the Sustainable Development Goals (SDGs) through investment in ecological infrastructure: A case study of South Africa. Ecosystem Services 27:253–260. doi: 10.1016/j.ecoser.2017.05.005

da Silva JMC, Wheeler E (2017) Ecosystems as infrastructure. Perspectives in Ecology and Conservation 15:32–35. doi: 10.1016/j.pecon.2016.11.005

Dal Ferro N, Cocco E, Lazzaro B, et al (2016) Assessing the role of agri-environmental measures to enhance the environment in the Veneto Region, Italy, with a model-based approach. Agriculture, Ecosystems and Environment 232:312–325. doi: 10.1016/j.agee.2016.08.010

Davis D, Gartside DF (2001) Challenges for economic policy in sustainable management of marine natural resources. Ecological Economics 36:223–236. doi: 10.1016/S0921-8009(00)00251-2

De Groot RS, Blignaut J, van der Ploeg S, et al (2013) Benefits of Investing in Ecosystem Restoration. Conservation Biology 27:1286–1293. doi: 10.1111/cobi.12158

de Krom MPMM (2017) Farmer participation in agri-environmental schemes: Regionalisation and the role of bridging social capital. Land Use Policy 60:352–361. doi: 10.1016/j.landusepol.2016.10.026

de Lima LS, Krueger T, García-Marquez J (2017) Uncertainties in demonstrating environmental benefits of payments for ecosystem services. Ecosystem Services 27:139–149. doi:

10.1016/j.ecoser.2017.09.005

DEA, SANBI (2016) Strategic Framework and Overarching Implementation Plan for Ecosystem-Based Adaptation (EbA) in South Africa

Department of Environmental Affairs 2012 (2012) Department of Environmental Affairs. Strategic plan: 1 April 2012 to 31 March 2017

Diswandi D (2017) A hybrid Coasean and Pigouvian approach to Payment for Ecosystem Services Program in West Lombok: Does it contribute to poverty alleviation? Ecosystem Services 23:138–145. doi: 10.1016/j.ecoser.2016.12.005

Doko T, Chen W, Sasaki K, Furutani T (2016) An attempt to develop an Environmental Information System of Ecological Infrastructure for evaluating functions of Ecosystem-Based Solutions for Disaster Risk Reduction (ECO-DRR). ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences XLI-B8:43–49. doi: 10.5194/isprsarchives-XLI-B8-43-2016

dos Santos RF, Antunes P, Ring I, Clemente P (2015) Engaging Local Private and Public Actors in Biodiversity Conservation: The role of Agri-Environmental schemes and Ecological fiscal transfers. Environmental Policy and Governance 96:83–96. doi: 10.1002/eet.1661

Duke JM, Dundas SJ, Messer KD (2013) Cost-effective conservation planning: Lessons from economics. Journal of Environmental Management 125:126–133. doi: 10.1016/j.jenvman.2013.03.048

Duong NTB, de Groot WT (2018) Distributional risk in PES: Exploring the concept in the Payment for Environmental Forest Services program, Vietnam. Forest Policy and Economics 92:22–32. doi: 10.1016/j.forpol.2018.03.008

DuPont CM, Levitt JN, Bilmes LJ (2016) Green Bonds and Land Conservation: The Evolution of a New Financing Tool. Harvard Environmental Economics Program

Elmqvist T, Maltby E, Barker T, et al (2010) Biodiversity, Ecosystems and Ecosystem Services

Farber SC, Costanza R, Wilson MA (2002) Economic and ecological concepts for valuing ecosystem services. Ecological Economics 41:375–392

Farley J (2010) Conservation Through the Economics Lens. Environmental Management 45:26–38. doi: 10.1007/s00267-008-9232-1

Farley J, Costanza R (2010) Payments for ecosystem services: From local to global. Ecological Economics 69:2060–2068. doi: 10.1016/j.ecolecon.2010.06.010

Feng D, Liang L, Wu W, et al (2018) Factors influencing willingness to accept in the paddy land-to-dry land program based on contingent value method. Journal of Cleaner Production 183:392–402. doi: 10.1016/j.jclepro.2018.02.142

Ferraza JC, Coutinho L (2017) Investment policies, development finance and economic transformation: Lessons from BNDES. Structural Change and Economic Dynamics. doi: 10.1016/j.strueco.2017.11.008

Fisher B, Turner RK, Morling P (2009) Defining and classifying ecosystem services for decision making. Ecological Economics 68:643–653. doi: 10.1016/j.ecolecon.2008.09.014

Fletcher R, Breitling J (2012) Market mechanism or subsidy in disguise? Governing payment for environmental services in Costa Rica. Geoforum 43:402–411. doi:

10.1016/j.geoforum.2011.11.008

Forsyth G, Kruger FJ, Le Maitre DC (2010) National Veldfire Risk Assessment: Analysis of exposure of social, economic and environmental assets to veldfire hazards in South Africa

Franks JR, Emery SB (2013) Incentivising collaborative conservation: Lessons from existing environmental Stewardship Scheme options. Land Use Policy 30:847–862. doi: 10.1016/j.landusepol.2012.06.005

Franzén F, Hammer M, Balfors B (2015) Institutional development for stakeholder participation in local water management—An analysis of two Swedish catchments. Land Use Policy 43:217–227. doi: 10.1016/j.landusepol.2014.11.013

Froger G, Ménard S, Méral P (2015) Towards a comparative and critical analysis of biodiversity banks. Ecosystem Services 15:152–161. doi: 10.1016/j.ecoser.2014.11.018

Galbraith SM, Hall TE, Tavárez HS, et al (2017) Local ecological knowledge reveals effects of policy-driven land use and cover change on beekeepers in Costa Rica. Land Use Policy 69:112–122. doi: 10.1016/j.landusepol.2017.08.032

Gallo JA, Pasquini L, Reyers B, Cowling RM (2009) The role of private conservation areas in biodiversity representation and target achievement within the Little Karoo region, South Africa. Biological Conservation 142:446–454. doi: 10.1016/j.biocon.2008.10.025

García-Llorente M, Martín-López B, Montes C (2011) Exploring the motivations of protesters in contingent valuation: Insights for conservation policies. Environmental Science and Policy 14:76–88. doi: 10.1016/j.envsci.2010.11.004

Gartner T, Mulligan J, Schmidt R, Gunn J (2013) Natural Infrastructure: Investing in Forested Landscapes for Source Water Protection in the United States. Earth Economics

Giordano T, Blignaut J, Marais C (2012) Natural resource management—an employment catalyst: The case of South Africa. Development Bank of Southern Africa

Glumac B, Han Q, Schaefer W, Van Der Krabben E (2015) Negotiation issues in forming public–private partnerships for brownfield redevelopment: Applying a game theoretical experiment. Land Use Policy 47:66–77. doi: 10.1016/j.landusepol.2015.03.018

Gómez-baggethun E, Muradian R (2015) In markets we trust? Setting the boundaries of Market-Based Instruments in ecosystem services governance. Ecological Economics 117:217–224. doi: 10.1016/j.ecolecon.2015.03.016

Grima N, Singh SJ, Smetschka B, Ringhofer L (2016) Payment for Ecosystem Services (PES) in Latin America: Analysing the performance of 40 case studies. Ecosystem Services 17:24–32. doi: 10.1016/j.ecoser.2015.11.010

Guillet F, Semal L (2018) Policy flaws of biodiversity offsetting as a conservation strategy. Biological Conservation 221:86–90. doi: 10.1016/j.biocon.2018.03.001

Haddaway NR (2015) A call for better reporting of conservation research data for use in meta-analyses. Conservation Biology 00:1–4. doi: 10.1111/cobi.12449

Haddaway NR, Macura B, Whaley P, Pullin AS (2018) ROSES Reporting standards for Systematic Evidence Syntheses: Pro forma, flow-diagram and descriptive summary of the plan and conduct of environmental systematic reviews and systematic maps. Environmental Evidence 7:4–11. doi: 10.1186/s13750-018-0121-7

Hajkowicz S (2009) The evolution of Australia's natural resource management programs: Towards improved targeting and evaluation of investments. Land Use Policy 26:471–478. doi: 10.1016/j.landusepol.2008.06.004

Hansson A, Pedersen E, Weisner SEB (2012) Landowners' incentives for constructing wetlands in an agricultural area in south Sweden. Journal of Environmental Management 113:271–278. doi: 10.1016/j.jenvman.2012.09.008

Hardy MJ, Bekessy SA, Fitzsimons JA, et al (2018) Protecting nature on private land using revolving funds: Assessing property suitability. Biological Conservation 220:84–93. doi: 10.1016/j.biocon.2018.01.026

Harrington E, Hsu D (2018) Roles for government and other sectors in the governance of green infrastructure in the U.S. Environmental Science and Policy 88:104–115. doi: 10.1016/j.envsci.2018.06.003

Hausknost D, Grima N, Jit S (2017) The political dimensions of Payments for Ecosystem Services (PES): Cascade or stairway? Ecological Economics 131:109–118. doi: 10.1016/j.ecolecon.2016.08.024

Hayes T, Murtinho F (2018) Communal governance, equity and payment for ecosystem services. Land Use Policy 79:123–136. doi: 10.1016/j.landusepol.2018.08.001

Hein L, Miller DC, Groot R De (2013) Payments for ecosystem services and the financing of global biodiversity conservation. Current Opinion in Environmental Sustainability 5:87–93. doi: 10.1016/j.cosust.2012.12.004

Hejnowicz AP, Raffaelli DG, Rudd MA, White PCL (2014) Evaluating the outcomes of payments for ecosystem services programmes using a capital asset framework. Ecosystem Services 9:83–97. doi: 10.1016/j.ecoser.2014.05.001

Herzon I, Birge T, Allen B, et al (2018) Time to look for evidence: Results-based approach to biodiversity conservation on farmland in Europe. Land Use Policy 71:347–354. doi: 10.1016/j.landusepol.2017.12.011

Higgins S, Turpie J, Costanza R, et al (1997) An ecological economic simulation model of mountain fynbos ecosystems Dynamics, valuation and management. Ecological Economics 22:155–169

Holmes PM, Richardson DM, Esler KJ, et al (2005) A decision-making framework for restoring riparian zones degraded by invasive alien plants in South Africa. South African Journal of Science 553–564

Houdet J, Trommetter M, Weber J (2012) Understanding changes in business strategies regarding biodiversity and ecosystem services. Ecological Economics 73:37–46. doi: 10.1016/j.ecolecon.2011.10.013

Hrabanski M (2015) The biodiversity offsets as market-based instruments in global governance: Origins, success and controversies. Ecosystem Services 15:143–151. doi: 10.1016/j.ecoser.2014.12.010

Iftekhar S, Polyakov M, Ansell D, et al (2016) How economics can further the success of ecological restoration. Conservation Biology 31:261–268. doi: 10.1111/cobi.12778

Iranah P, Lal P, Wolde BT, Burli P (2018) Valuing visitor access to forested areas and exploring willingness to pay for forest conservation and restoration finance: The case of small island

developing state of Mauritius. Journal of Environmental Management 223:868–877. doi: 10.1016/j.jenvman.2018.07.008

Jespersen K, Gallemore C (2018) The Institutional Work of Payments for Ecosystem Services: Why the Mundane Should Matter. Ecological Economics 146:507–519. doi: 10.1016/j.ecolecon.2017.12.013

Johnson MK, Lien AM, Sherman NR, López-Hoffman L (2018) Barriers to PES programs in Indigenous communities: A lesson in land tenure insecurity from the Hopi Indian reservation. Ecosystem Services 32:62–69. doi: 10.1016/j.ecoser.2018.05.009

Jones KW, Avila Foucat S, Pischke EC, et al (2019) Exploring the connections between participation in and benefits from payments for hydrological services programs in Veracruz State, Mexico. Ecosystem Services 35:32–42. doi: 10.1016/j.ecoser.2018.11.004

Kanchanaroek Y, Aslam U (2018) Policy schemes for the transition to sustainable agriculture — Farmer preferences and spatial heterogeneity in northern Thailand. Land Use Policy 78:227–235. doi: 10.1016/j.landusepol.2018.05.026

Kemkes RJ, Farley J, Koliba CJ (2010) Determining when payments are an effective policy approach to ecosystem service provision. Ecological Economics 69:2069–2074. doi: 10.1016/j.ecolecon.2009.11.032

Kleijn D, Baquero RA, Clough Y, et al (2006) Mixed biodiversity benefits of agri-environment schemes in five European countries. Ecology Letters 9:243–254. doi: 10.1111/j.1461-0248.2005.00869.x

Kleijn D, Sutherland WJ (2003) How effective are European agri-environment schemes in conserving and promoting biodiversity? Journal of Applied Ecology 947–969

Kohl C, Mcintosh EJ, Unger S, et al (2018) Online tools supporting the conduct and reporting of systematic reviews and systematic maps: a case study on CADIMA and review of existing tools. Environmental Evidence 7:1–17. doi: 10.1186/s13750-018-0115-5

Kok MTJ, Alkemade R, Bakkenes M, et al (2018) Pathways for agriculture and forestry to contribute to terrestrial biodiversity conservation: A global scenario-study. Biological Conservation 221:137–150. doi: 10.1016/j.biocon.2018.03.003

Kolinjivadi V, Adamowski J, Kosoy N (2014) Recasting payments for ecosystem services (PES) in water resource management: A novel institutional approach. Ecosystem Services 10:144–154. doi: 10.1016/j.ecoser.2014.08.008

Kopsidas O, Hadjixenofontos A (2018) Economic Analysis of the Internalization the Externalities in Environmental Goods. Journal of Environmental Science and Engineering 422–429. doi: 10.17265/2162-5298/2017.08.007

Kubiszewski I, Marais C, Costanza R (2017) Investing in ecological infrastructure in South Africa. Ecosystem Services 27:A1–A2. doi: 10.1016/j.ecoser.2017.07.009

Kuhfuss L, Subervie J (2018) Do European Agri-environment Measures Help Reduce Herbicide Use? Evidence From Viticulture in France. Ecological Economics 149:202–211. doi: 10.1016/j.ecolecon.2018.03.015

Kull CA, Arnauld de Sartre X, Castro-Larrañaga M (2015) The political ecology of ecosystem services. Geoforum 61:122–134. doi: 10.1016/j.geoforum.2015.03.004

Kumar P, Kumar M, Garrett L (2014) Behavioural foundation of response policies for ecosystem management: What can we learn from Payments for Ecosystem Services (PES). Ecosystem Services 10:128–136. doi: 10.1016/j.ecoser.2014.10.005

Lamarque P, Lambin EF (2015) The effectiveness of marked-based instruments to foster the conservation of extensive land use: The case of Geographical Indications in the French Alps. Land Use Policy 42:706–717. doi: 10.1016/j.landusepol.2014.10.009

Lambooy T, Levashova Y (2011) Opportunities and challenges for private sector entrepreneurship and investment in biodiversity, ecosystem services and nature conservation. International Journal of Biodiversity Science, Ecosystem Services and Management 7:301–318. doi: 10.1080/21513732.2011.629632

Lange WJ De, Wilgen BW Van (2010) An economic assessment of the contribution of biological control to the management of invasive alien plants and to the protection of ecosystem services in South Africa. Biological Invasions. doi: 10.1007/s10530-010-9811-y

Lapeyre R, Froger G, Hrabanski M (2015) Biodiversity offsets as market-based instruments for ecosystem services? From discourses to practices. Ecosystem Services 15:125–133. doi: 10.1016/j.ecoser.2014.10.010

Latacz-Lohmann U, Hodge I (2003) European agri-environmental policy for the 21st century. The Australian Journal of Agricultural and Resource Economics 47:1:123–139

Lau WWY (2013) Beyond carbon: Conceptualizing payments for ecosystem services in blue forests on carbon and other marine and coastal ecosystem services. Ocean and Coastal Management 83:5–14. doi: 10.1016/j.ocecoaman.2012.03.011

Le Maitre DC, van Wilgen BW, Gelderblom CM, et al (2002) Invasive alien trees and water resources in South Africa : case studies of the costs and benefits of management. Forest Ecology and Management 160:143–159

Lee JA, Chon J, Ahn C (2014) Planning Landscape Corridors in Ecological Infrastructure Using Least-Cost Path Methods Based on the Value of Ecosystem Services. Sustainability 6:7564–7585. doi: 10.3390/su6117564

Leventon J, Schaal T, Velten S, et al (2017) Collaboration or fragmentation? Biodiversity management through the common agricultural policy. Land Use Policy 64:1–12. doi: 10.1016/j.landusepol.2017.02.009

Liu P, Yin R, Zhao M (2019) Reformulating China's ecological restoration policies: What can be learned from comparing Chinese and American experiences? Forest Policy and Economics 98:54–61. doi: 10.1016/j.forpol.2018.05.013

Liu Z, Kontoleon A (2018) Meta-Analysis of Livelihood Impacts of Payments for Environmental Services Programmes in Developing Countries. Ecological Economics 149:48–61. doi: 10.1016/j.ecolecon.2018.02.008

Ma Z, Clarke M, Church SP (2018) Insights into individual and cooperative invasive plant management on family forestlands. Land Use Policy 75:682–693. doi: 10.1016/j.landusepol.2018.02.010

Marais C, Maitre D Le, Frost P (2015) The Working on Fire Programme: mainstreaming integrated veld and forest fire management into economic development. XIV WORLD FORESTRY CONGRESS

Marais C, Wannenburgh AM (2008) Restoration of water resources (natural capital) through the clearing of invasive alien plants from riparian areas in South Africa - Costs and water benefits. South African Journal of Botany 74:526–537. doi: 10.1016/j.sajb.2008.01.175

Marchant SC (2014) Investing in ecological infrastructure: A framework for Sustainable Development

Martin-Ortega J, Ojea E, Roux C (2013) Payments for water ecosystem services in Latin America: A literature review and conceptual model. Ecosystem Services 6:122–132. doi: 10.1016/j.ecoser.2013.09.008

Maze K, Barnett M, Botts EA, et al (2013) Making the case for biodiversity in South Africa: Re-framing biodiversity communications. Bothalia - African Biodiversity & Conservation 1–8

McElwee P, Nghiem T, Le H, et al (2014) Payments for environmental services and contested neoliberalisation in developing countries: A case study from Vietnam. Journal of Rural Studies 36:423–440. doi: 10.1016/j.jrurstud.2014.08.003

Mcwilliam W, Balzarova M (2017) The role of dairy company policies in support of farm green infrastructure in the absence of government stewardship payments. Land Use Policy 68:671–680. doi: 10.1016/j.landusepol.2017.08.030

MEA (2005) Ecosystems and Human WellBeing-Synthesis. Washington, DC

Meyer C, Schomers S, Matzdorf B, et al (2016) Civil society actors at the nexus of the ecosystem services concept and agri-environmental policies. Land Use Policy 55:352–356. doi: https://doi.org/10.1016/j.landusepol.2015.11.003

Midler E, Pascual U, Drucker AG, et al (2015) Unraveling the effects of payments for ecosystem services on motivations for collective action. Ecological Economics 120:394–405. doi: 10.1016/j.ecolecon.2015.04.006

Mills J, Gaskell P, Ingram J, Chaplin S (2018) Understanding farmers' motivations for providing unsubsidised environmental benefits. Land Use Policy 76:697–707. doi: 10.1016/j.landusepol.2018.02.053

Moher D, Liberati A, Tetzlaff J, Douglas GA (2009) Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. RESEARCH METHODS & REPORTING 18:264–268. doi: 10.1136/bmj.b2535

Moon K, Cocklin C (2011) Participation in biodiversity conservation: Motivations and barriers of Australian landholders. Journal of Rural Studies 27:331–342. doi: 10.1016/j.jrurstud.2011.04.001

Moros L, Alejandra M, Corbera E (2019) Payments for Ecosystem Services and Motivational Crowding in Colombia's Amazon Piedmont. Ecological Economics 156:468–488. doi: 10.1016/j.ecolecon.2017.11.032

Nalau J, Becken S, Mackey B (2018) Ecosystem-based Adaptation: A review of the constraints. Environmental Science and Policy 89:357–364. doi: 10.1016/j.envsci.2018.08.014

NatureVest (2014) Investing in Conservation: A landscape assessment of an emerging market. The Nature Conservancy of California

Neilsen MR, Theilade I, Meilby H, et al (2018) Can PES and REDD+ match Willingness To Accept payments in contracts for reforestation and avoided forest degradation? The case

of farmers in upland Bac Kan, Vietnam. Land Use Policy 79:822–833. doi: 10.1016/j.landusepol.2018.09.010

Nielsen ASE, Jacobsen JB, Strange N (2018) Landowner participation in forest conservation programs: A revealed approach using register, spatial and contract data. Journal of Forest Economics 30:1–12

Obeng EA, Aguilar FX (2018) Value orientation and payment for ecosystem services: Perceived detrimental consequences lead to willingness-to-pay for ecosystem services. Journal of Environmental Management 206:458–471. doi: 10.1016/j.jenvman.2017.10.059

Ostrom E, Cox M (2010) Moving beyond panaceas: a multi-tiered diagnostic approach for social-ecological analysis. Environmental Conservation 37:451–463. doi: 10.1017/S0376892910000834

Pagiola S (2006) Payments for Environmental Services in Costa Rica Stefano. World Bank 1–12

Pagiola S, Ramírez E, Gobbi J, et al (2007) Paying for the environmental services of silvopastoral practices in Nicaragua. Ecological Economics 64:374 – 385. doi: 10.1016/j.ecolecon.2007.04.014

Paudyal K, Baral H, Prasad S, John R (2018) Design considerations in supporting payments for ecosystem services from community-managed forests in Nepal. Ecosystem Services 30:61–72. doi: 10.1016/j.ecoser.2018.01.016

Pettersson M, Keskitalo ECH (2013) Adaptive capacity of legal and policy frameworks for biodiversity protection considering climate change. Land Use Policy 34:213–222. doi: 10.1016/j.landusepol.2013.03.007

Pham TT, Loft L, Bennett K, et al (2015) Monitoring and evaluation of Payment for Forest Environmental Services in Vietnam: From myth to reality. Ecosystem Services 16:220–229. doi: 10.1016/j.ecoser.2015.10.016

Polasky S (2008) Why conservation planning needs socioeconomic data. The National Academy of Sciences of the USA 105:6505–6506

Polasky S, Nelson E, Camm J, et al (2008) Where to put things? Spatial land management to sustain biodiversity and economic returns. Biological Conservation 141:1505–1524. doi: 10.1016/j.biocon.2008.03.022

Primdahl J, Vesterager JP, Finn JA, et al (2010) Current use of impact models for agri-environment schemes and potential for improvements of policy design and assessment. Journal of Environmental Management 91:1245–1254. doi: 10.1016/j.jenvman.2009.12.012

Pullin AS, Stewart GB (2007) Guidelines for Systematic Review in Conservation and Environmental Management. Conservation Biology 20:1647–1656. doi: 10.1111/j.1523-1739.2006.00485.x

Reed MS, Moxey A, Prager K, et al (2014) Improving the link between payments and the provision of ecosystem services in agri-environment schemes. Ecosystem Services 9:44–53. doi: 10.1016/j.ecoser.2014.06.008

Richardson DM, van Wilgen BW (2004) Invasive alien plants in South Africa: how well do we understand the ecological impacts? South African Journal of Science 100:45–52

Riley M, Sangster H, Smith H, et al (2018) Will farmers work together for conservation? The potential limits of farmers' cooperation in agri-environment measures. Land Use Policy 70:635–646. doi: https://doi.org/10.1016/j.landusepol.2017.10.049

Roberts M, Cresswell W, Hanley N (2018) Prioritising Invasive Species Control Actions: Evaluating Effectiveness, Costs, Willingness to Pay and Social Acceptance. Ecological Economics 152:1–8. doi: 10.1016/j.ecolecon.2018.05.027

Rode J, Wittmer H, Emerton L, Schröter-Schlaack C (2016) 'Ecosystem service opportunities': A practice-oriented framework for identifying economic instruments to enhance biodiversity and human livelihoods. Journal for Nature Conservation 33:35–47. doi: 10.1016/j.jnc.2016.07.001

Russi D, Margue H, Oppermann R, Keenleyside C (2016) Result-based agri-environment measures: Market-based instruments, incentives or rewards? The case of Baden-Württemberg. Land Use Policy 54:69–77. doi: 10.1016/j.landusepol.2016.01.012

Salles GS, Salinas DTP, Paulino SR (2017) How Funding Source Influences the Form of REDD+ Initiatives: The Case of Market Versus Public Funds in Brazil. Ecological Economics 139:91–101. doi: 10.1016/j.ecolecon.2017.04.003

SANBI (2014a) A Framework for Investing in Ecological Infrastructure in South Africa

SANBI (2014b) A Framework for Investing in Ecological Infrastructure in South Africa. South African National Biodiversity Institute

Sattler C, Trampnau S, Schomers S, et al (2013) Multi-classification of payments for ecosystem services: How do classification characteristics relate to overall PES success? Ecosystem Services 6:31–45. doi: 10.1016/j.ecoser.2013.09.007

Schirpke U, Marino D, Marucci A, Palmieri M (2018) Positive effects of payments for ecosystem services on biodiversity and socio-economic development: Examples from Natura 2000 sites in Italy. Ecosystem Services 34:96–105. doi: 10.1016/j.ecoser.2018.10.006

Schomers S, Matzdorf B (2013) Payments for ecosystem services: A review and comparison of developing and industrialized countries. Ecosystem Services 6:16–30. doi: 10.1016/j.ecoser.2013.01.002

Schroeder LA, Isselstein J, Chaplin S, Peel S (2013) Agri-environment schemes: Farmers' acceptance and perception of potential "Payment by Results" in grassland-A case study in England. Land Use Policy 32:134–144. doi: 10.1016/j.landusepol.2012.10.009

Shackleton RT, Angelstamb P, van der Waalc B, Elbakidzeb M (2017) Progress made in managing and valuing ecosystem services: a horizon scan of gaps in research, management and governance. Ecosystem Services 0–1. doi: 10.1016/j.ecoser.2016.11.020

Sheremet O, Ruokamo E, Juutinen A, et al (2018) Incentivising Participation and Spatial Coordination in Payment for Ecosystem Service Schemes: Forest Disease Control Programs in Finland. Ecological Economics 152:260–272. doi: 10.1016/j.ecolecon.2018.06.004

Sidemo-Holm W, Smith HG, Brady M V. (2018) Improving agricultural pollution abatement through result-based payment schemes. Land Use Policy 77:209–219. doi: 10.1016/j.landusepol.2018.05.017

Smith G, Day B (2018) Addressing the Collective Action Problem in Multiple-purchaser PES: An Experimental Investigation of Negotiated Payment Contributions. Ecological Economics 144:36–58. doi: 10.1016/j.ecolecon.2017.07.020

Sommerville MM, Milner-Gulland EJ, Jones JPG (2011) The challenge of monitoring biodiversity in payment for environmental service interventions. Biological Conservation 144:2832–2841. doi: 10.1016/j.biocon.2011.07.036

Spergel B, Moye M (2004) Financing marine conservation: A menu of options

Sterling EJ, Betley E, Sigouin A, et al (2017) Assessing the evidence for stakeholder engagement in biodiversity conservation. Biological Conservation 209:159–171. doi: 10.1016/j.biocon.2017.02.008

Sullivan S (2013) Banking Nature? The Spectacular Financialisation of Environmental Conservation. Wiley Online Library 45:198–217. doi: 10.1111/j.1467-8330.2012.00989.x

Sumaila UR, Rodriguez CM, Schultz M, et al (2017) Investments to reverse biodiversity loss are economically beneficial. Current Opinion in Environmental Sustainability 29:82–88. doi: 10.1016/j.cosust.2018.01.007

Sutherland WJ, Pullin AS, Dolman PM, Knight TM (2004) The need for evidence-based conservation. Opinion-Trends in Ecology and Evolution 19:4–7. doi: 10.1016/j.tree.2004.03.018

Sweikert LA, Gigliotti LM (2019) Evaluating the role of Farm Bill conservation program participation in conserving America's grasslands. Land Use Policy 81:392–399. doi: 10.1016/j.landusepol.2018.10.023

Taylor BM, Grieken M Van (2015) Local institutions and farmer participation in agri-environmental schemes. Journal of Rural Studies 37:10–19. doi: 10.1016/j.jrurstud.2014.11.011

Thompson BS (2017) Can Financial Technology Innovate Benefit Distribution in Payments for Ecosystem Services and REDD+? Ecological Economics 139:150–157. doi: 10.1016/j.ecolecon.2017.04.008

To P, Dressler W (2019) Rethinking 'success': The politics of payment for forest ecosystem services in Vietnam. Land Use Policy 81:582–593. doi: 10.1016/j.landusepol.2018.11.010

Tschirhart J (2009) Integrated Ecological-Economic Models. Annual Review of Resource Economics 28:28.1–28:1–28. doi: 10.1146/annurev.resource.050708.144113

Turpie J (2004) The role of resource economics in the control of invasive alien plants in South Africa. South African Journal of Science 100:87–93

Turpie J, Marais C, Blignaut J (2007) The working for water programme: Evolution of a payments for ecosystem services mechanism that addresses both poverty and ecosystem service delivery in South Africa. Ecological Economics 65:788–798

van der Horst D (2011) Adoption of payments for ecosystem services: An application of the Hägerstrand model. Applied Geography 31:668–676. doi: 10.1016/j.apgeog.2010.12.001

van Wilgen BW, Cowling RM, Marais C, et al (2012) Challenges in invasive alien plant control in South Africa. South African Journal of Science 108:11–13

van Wilgen BW, Khan A, Marais C (2011) Changing Perspectives on Managing Biological

Invasions: Insights from South Africa and the Working for Water Programme. Fifty Years of Invasion Ecology: The Legacy of Charles Elton First edit:377–394

van Wilgen BW, Richardson DM, Le Maitre DC, et al (2001) The economic consequences of alien plant invasions: examples of impacts and approaches to sustainable management in South Africa. Environment, Development and Sustainability 3:145–168

van Wilgen BW, Wannenburgh A (2016) Co-facilitating invasive species control, water conservation and poverty relief: achievements and challenges in South Africa's Working for Water programme. Current Opinion in Environmental Sustainability 19:7–17. doi: 10.1016/j.cosust.2015.08.012

Vatn A (2018) Environmental Governance–From Public to Private? Ecological Economics 148:170–177. doi: 10.1016/j.ecolecon.2018.01.010

Verbič M, Slabe-Erker R (2008) An econometric analysis of willingness-to-pay for sustainable development: A case study of the Volčji Potok landscape area. Ecological Economics 68:1316–1328. doi: 10.1016/j.ecolecon.2008.09.002

Voora VA, Venema HD (2008) The Natural Capital Approach: A Concept Paper. International Institute for Sustainable Development

Wallace KJ (2007) Classification of ecosystem services: Problems and solutions. Biological Conservation 139:235–246. doi: 10.1016/j.biocon.2007.07.015

Weikard H, Kis A, Ungvári G (2017) A simple compensation mechanism for flood protection services on farmland. Land Use Policy 65:128–134. doi: 10.1016/j.landusepol.2017.04.006

Welsh R, Webb ME, Langen TA (2018) Factors affecting landowner enrollment in wetland restoration in northeastern New York State. Land Use Policy 76:679–685. doi: 10.1016/j.landusepol.2018.02.051

West S, Cairns R, Schultz L (2016) What constitutes a successful biodiversity corridor? A Q-study in the Cape Floristic Region, South Africa. Biological Conservation 198:183–192. doi: 10.1016/j.biocon.2016.04.019

Wilson A, Vickery J, Pendlebury C (2007) Agri-environment schemes as a tool for reversing declining populations of grassland waders: Mixed benefits from Environmentally Sensitive Areas in England. Biological Conservation 136:128–135. doi: 10.1016/j.biocon.2006.11.010

Wunder S (2005) Payments for environmental services: Some nuts and bolts. Center for International Forestry Research

Yang W, Bryan BA, MacDonald DH, et al (2010) A conservation industry for sustaining natural capital and ecosystem services in agricultural landscapes. Ecological Economics 69:680–689. doi: 10.1016/j.ecolecon.2009.11.028

Yeboah KF, Lupi F, Kaplowitz MD (2015) Agricultural landowners' willingness to participate in a filter strip program for watershed protection. Land Use Policy 49:75–85. doi: 10.1016/j.landusepol.2015.07.016

Zammit C (2013) Landowners and conservation markets: Social benefits from two Australian government programs. Land Use Policy 31:11–16. doi: 10.1016/j.landusepol.2012.01.011

Zhang L, Hu J, Li Y, Pradhan NS (2018) Public-private partnership in enhancing farmers' adaptation to drought: Insights from the Lujiang Flatland in the Nu River (Upper Salween)

valley, China. Land Use Policy 71:138–145. doi: 10.1016/j.landusepol.2017.11.034

Zhang X, Han L (2018) Which Factors Affect Farmers' Willingness for rural community remediation? A tale of three rural villages in China. Land Use Policy 74:195–203. doi: 10.1016/j.landusepol.2017.08.014

Zimmermann A, Britz W (2016) European farms' participation in agri-environmental measures. Land Use Policy 50:214–228

# Appendices

**Appendix 1.** Systematic Review Protocol (SRP) define the objectives of the review, review questions, criteria for inclusion and exclusion of sources and keywords.

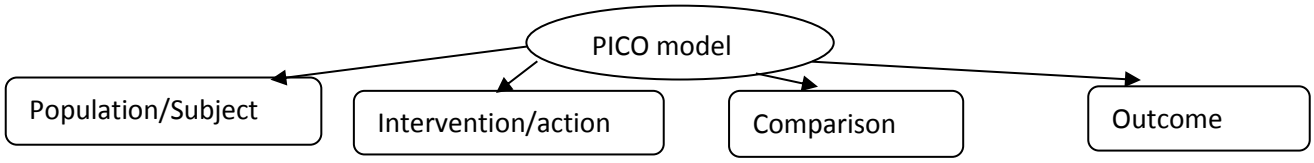
## [i]A protocol for a systematic literature review

### Research question
How to unlock and secure Ecological Infrastructure (EI) investments through policy framework and partnerships with private landowners?

### Eligibility criteria
Peer-reviewed journals and grey literature reports written on partnerships investments made to support Ecological Infrastructure maintenance and restoration. Sources covering one of the key aspects (1) developmental need for EI investments (2) desire from private landowners to cooperate (3) Policy support to encourage EI protection cooperation.

### Search strategy
**Key concepts:**
1. Ecological infrastructure
2. Investments
3. Policy framework

### PICO model
Over search strategy models/tools available (e.g. SPICE, ECLIPSE, SPIDER), a PICO model (Population/problem, Interventions, Comparison, Outcomes) was chosen to break down the search words and enable the researcher to define the qualitative research question and lay the pathway for a systematic search strategy (Pullin and Stewart 2007).




### Sources
Science Direct, Scopus, Web of Science and Google search engine.
Searching other resources: Snowballing will be conducted to add more studies, relevant reviews, reports, and other grey literature for relevant references.

### Validity
Include the sources that document collaborative partnerships towards EI maintenance and restoration. Exclude non-English papers. No restriction on publication year due to the newness of the EI concept.

### Data extraction and management
A customised PRISMA workflow will be used to screen studies. This process will review the titles, abstracts, and keywords. Irrelevant studies will be excluded after reading the titles and abstracts and on indication that they do not meet the inclusion criteria described above. Relevant articles will proceed to the full review.

### Data analysis
Mix coding approach will be conducted deductively and inductively, the former approach will code (1) developmental needs of EI investments, (2) desires to invest and (3) policy support mechanisms. The latter will extract ideas found in order to generate the emerging theory from the literature. Atlas.ti will be used for qualitative analysis.

**Appendix 2.** A summary of literature sources chosen for the review from different databases.

| Literature source | Number of papers |
|---|---|
| Land Use Policy | 74 |
| Ecological Economics | 44 |
| Ecosystem Services | 15 |
| Environmental Management | 4 |
| Biological Conservation | 4 |
| Forest Policy and Economics | 3 |
| Environmental Science and Policy | 3 |
| Agriculture, Ecosystem and Environment | 3 |
| Landscape and Urban Planning | 2 |
| Environmental Sustainability | 2 |
| Cleaner Production | 2 |
| Water Resources and Economics | 1 |
| Structural Change and Economic Dynamic | 1 |
| Science of the Total Environment | 1 |
| Ocean and Coastal Management | 1 |
| GeoForum | 1 |
| Ecology and Conservation | 1 |
| Disaster Risk and Reduction | 1 |
| Agricultural and Resource Economics | 1 |
| **Grey literature** | |
| Encyclopedia of Agriculture and Food System | 1 |
| NatureVest: Natural Capital Investment Solution | 1 |

**Appendix 3.** Systematic Review Protocol of Payments for Ecosystem Services
**A protocol for a systematic review**

## Research question

What elements optimised, complicated and hindered the execution of Payments for Ecosystems Services (PES) schemes towards conservation outcomes and ecological integrity?

## Eligibility criteria

Peer-reviewed journals and reports written on Payments for Ecosystem Services particularly the successes, challenges, and failures.

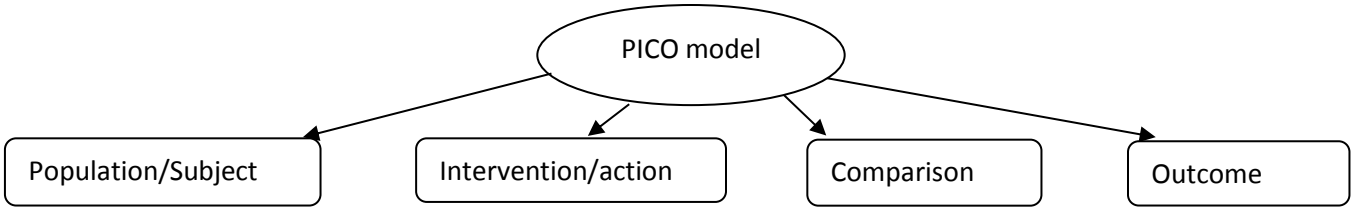
Search strategy

**Key concepts:**

Payments for Ecosystem Services successes
Payment for Ecosystem Service challenges
Payment for Ecosystem Services failures

## PICO model

Over search strategy models/tools available (e.g. SPICE, ECLIPSE, SPIDER), a PICO model (Population/problem, Interventions, Comparison, Outcomes) was chosen to 'break down the search words and enable the researchers to define the qualitative research question and lay the pathway for a systematic search strategy (Pullin and Stewart 2007)'.




## Keywords

| *Assessment of the successes of PES schemes for their ability to ensure efficient and effective environmental governance* | *Review of multiple challenges and difficulties of PES schemes in demonstrating the business case for investments* | *Review of failures of PES schemes based on decisions made by developers* |
|---|---|---|
| *"payment* for ecosystem* service*" OR*<br>*"payment* for environment* service*" OR*<br>*"payment* for ecol* service*"*<br>*AND*<br>*"succe*" OR*<br>*"achiev*" OR*<br>*"impact*" OR*<br>*"effect*" OR*<br>*"accomplish*" OR*<br>*"strength*" OR*<br>*"highlight*" OR*<br>*"opportunit*" OR*<br>*"benefit*" OR*<br>*"positiv*"* | *"payment* for ecosystem* service*" OR*<br>*"payment* for environment* service*"*<br>*OR*<br>*"payment* for ecol*service*"*<br>*AND*<br>*"difficult*" OR*<br>*"challeng*" OR*<br>*"hind*" OR*<br>*"barrier*" OR*<br>*"constrain*" OR*<br>*"limit*" OR*<br>*"threat*"* | *"payment* for ecosystem*<br>service*" OR*<br>*"payment* for environment*<br>service*" OR*<br>*"payment* for ecol*service*"*<br>*AND*<br>*"fail*" OR*<br>*"risk*" OR*<br>*"weak*" OR*<br>*"negative*"* |

### Sources
Science Direct, Scopus, Web of Science and Google search engine.
Searching other resources: Snowballing was conducted to add more studies, relevant reviews, reports, and other grey literature for relevant references.

### Validity
Include Payments for Ecosystem Services studies as a conservation mechanism. Exclude non-English papers.

### Data extraction and management
A customised ROSES workflow was used to screen studies. Article titles, abstracts, and keywords were reviewed. Irrelevant studies were excluded based on the eligibility criteria described above. Relevant articles were read in full.

### Data analysis
Mix coding approach was conducted deductively and inductively, the former approach coded the (1) successes (2) failures and (3) challenges of PES schemes. The latter was open to ideas found in order to generate the new emerging theory from the literature. Atlas.ti was used for qualitative analysis.

**Appendix 4.** Details of analysed sources that answered most of the questions asked in chapter 2. This database was used in the qualitative systematic literature review in order to synthesise the Ecological Infrastructure investment needs, willingness to invest and institutional support mechanisms at a global scale.

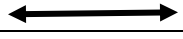
| Author(s) | Year | Location | PICO | Study type | Ecological Infrastructure investment needs or drivers | Ecological Infrastructure investment desire, willingness, contribution and capacity (public and private landowners) | Policy dimension and other supporting institutional mechanisms |
|---|---|---|---|---|---|---|---|
| Davis & Gartside 2001 | 2001 | Australia | Intervention | Survey | Curb the overexploitation and destruction of important marine assets in industries such as fishing and tourism. | Not defined | Economic instruments for managing marine natural resources and financial incentives. Unlike the traditional approach to managing natural resource problems, (apply regulations, 'command-and-control' approach where government measures (legislation) with which individuals or corporate entities must comply. |
| Verbi & Slabeerker 2008 | 2008 | Slovenia | Willingness | Analysis | Not defined | Determinants of willingness-to-pay include the respondent's income, the frequency of visiting the environmental goods, attitude to environmental goods. | Not defined |
| Yang et al. 2010 | 2010 | Australia | Outcomes | Survey | Not defined | The innovative use of market-based approaches to government investment in conservation has made substantial advances towards improved cost-effectiveness | Government investment programs; agricultural stewardship schemes and payments for ecosystem services aim to motivate conservation actions on private land to generate substantial public benefits, often occurring off-farm or downstream. |
| Primdahl et al. 2010 | 2010 | UK | Policy | Reviews | Paying directly for a clean and diverse environment. | Not defined | Agri-environment schemes are designed to address protection, maintenance, and enhancement of natural resources (water and soil), biodiversity (species and habitats) and landscape values. |
| Moon & Cocklin 2011 | 2011 | Australia | Comparator | Perspective | Not defined | Landholders' decisions to participate depended on the level of formal biodiversity protection, potential changes to their property rights, personal benefits of participation, conservation, production, financial and experimental imperatives. | Market-based economic instruments should be used, when there is a commitment to conservation by the landholders and program administrators and sufficient funding. Voluntary and economic policy instruments can be used to stimulate participation and to reduce the creation of perverse ecological outcomes. |
| Schroeder et al. 2013 | 2013 | England | Outcomes | Perspective | Lessen biodiversity deterioration, soil erosion, greenhouse gases and project water quality due to Agri-intensification. | Willingness was influenced by demographic, business and environmental features. (Age, education, size and type of a business/farm ownership). | The government financially supported Environmental Conservation through Agri-Environmental Schemes-a results and efficiency-driven approach. |
| Duke et al. 2013 | 2013 | US | Intervention | Review | To enhance Social Benefits to deliver enough ecosystem services | Not defined | Conservation policy was used to incentivise landowners to protect endangered species habitat, control erosion, improve water quality enhance riparian buffers, and expand wetlands. |
| Franks & Emery 2013 | 2013 | England | Intervention | Perspective | Not defined | Environmental Stewardship Scheme (ESS) | ESS was used to improve collaboration between local authorities, communities, statutory agencies, the voluntary and private sectors, farmers, land managers, and individual citizens to create Ecological Restoration Zones. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Zammit 2013 | 2013 | Australia | Intervention and Subject | Empirical | To restore and maintain endangered ecological communities | Incentives for private landowners to engage in active biodiversity conservation measures through cost-effective investments of public funds and build capacity to be effective conservation managers. | The Forest Conservation Fund and the Environmental Stewardship Program were funded by the government to target endangered ecological communities and secured contracts, landowners, to improve habitat condition. |
| Pettersson & Keskitalo 2013 | 2013 | EU/UK | Intervention | Policy analysis and review | Protection of biodiversity in general due to climate change, and a desire to halt biodiversity losses. | Not defined | Rules, regulations, substantive provisions that restrict access to, or prohibit the use of designated habitats and control activities. |
| Lapeyre et al. 2015 | 2015 | France | Policy | Analysis | Protect and deliver Ecosystem Services. | Farmers were encouraged to protected and generate Ecosystem Services through Market-Based Conservation Instruments (MBCIs). | Compensatory mitigation, biodiversity offsets, mitigation banking, habitat banking, species banking, wetlands mitigation, are Market-Based Conservation Instruments (MBCIs) for ecosystem services and compensation for damages from development. |
| Froger et al. 2015 | 2015 | France | Comparison | Analysis and comparison | To restore and protect wetlands, species, habitats, ecosystem services or functions. | Not defined | Biodiversity “banks” have been developed to provide biodiversity units or credits to offset environmental damage caused by economic development. |
| Yeboah et al. 2015 | 2015 | USA | Willingness | Empirical | Mitigate non-point source (NPS) pollution in a catchment | Willingness to participate in Agri-environmental programs was positively related to farm size, educational attainment, farmer’s interest and/or experience with conservation, environmental attitudes, access to and quality of information, perceived financial and farm-level related benefits. | Payments for Environmental Services (PES) were introduced by the government to encourage best management practices (BMPs) adoption for catchment protection and to control of NPS pollution and agricultural runoff. |
| Glumac et al. 2015 | 2015 | Netherlands | Intervention | Empirical | Limitations to public funding | Not defined | Public-private partnerships have led to governments to invite the private sector into various long-term arrangements for capital-intensive projects. |
| Bremer et al. 2016 | 2016 | Latin America | Intervention and Outcomes | Empirical | To promote long-term catchment conservation with multiple benefits for biodiversity and human well-being. | A legal mechanism catalysed participation. | Public funding secured through legislation provided the most funding, private sector, NGO, and development bank sources also supported |
| Russi et al. 2016 | 2016 | Germany | Policy | Perspective | Not defined | Farmers were motivated to join the scheme by the monetary incentives and ethical reasons. | Result-based Agri-environment measures to stimulate and improve the conditionality and efficiency of the use of CAP funding for environmental land management. They differ from action-based measures. |
| Mcwilliam & Balzarova 2017 | 2017 | New Zealand | Intervention | Empirical | Alleviate farming environmental impacts on terrestrial and freshwater ecosystems. | Farmers developed EI conservation policies with support from government-due to NGOs and public concerns. | The government encouraged the best farming practice through regulatory enforcement. |
| Galbraith et al. 2017 | 2017 | Costa Rica | Intervention | Perspective | Land Use and Cover (LUC) change is a major driver of ecosystem services loss worldwide. | Not defined | Policy- makers had designed conservation strategies that incentivised maintenance of LUC, ecosystem services provision and poverty reduction. |
| Krom 2017 | 2017 | Belgium | Interventions | Perspective | Sustainably integrate environmental production in | Farmers participated in the Agri-environmental schemes to enhance the long-term viability of their | Farmers were incentivised for conserving and enhancing the environment through Common Agricultural Policy (CAP) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | agricultural business development. | agricultural businesses through cooperative and, bridging social ties with other stakeholders. | |
| Weikard et al. 2017 | 2017 | Hungary | Intervention and Outcomes | Perspective Theoretical Analysis | Mitigate flooding risk due to Climate Change | Farmers' willingness to have their lands included in a conservation programme depended on the compensation they will obtain. | A proposed new compensation scheme consisted of an unconditional annual payment and a reparation payment conditional on flooding. |
| Piffer Salles et al. 2017 | 2017 | Brazil | Policy | Analysis | To generate Ecosystem Services (ES) to meet human needs, reduce carbon emissions and maintain biodiversity. | The willingness was driven by the use of Incentive-based economic instruments. | Reduce Emissions from Deforestation and Forest Degradation (REDD+) was used to provide economic incentives for the adoption of forest-based mitigation measures against global climate change. |
| Harrington & Hsu 2018 | 2018 | US | Intervention | Empirical | Address storm-water management challenges | Government and non-profit organizations collaborated to provide the funding to experiment green infrastructure technologies. | The government led green infrastructure through policy and political support and NGOs provided information |
| Feng et al. 2018 | 2018 | China | Intervention | Empirical | To protect catchment ecosystem services | Compensation was used to motivate local farmers to contribute to the conservation initiative. | Ecological compensation regulations and laws as well as environmental awareness for EI protection. |
| Zhang et al. 2018 | 2018 | China | Outcomes | Empirical | Mitigate drought caused by climate change scenarios. | Farmers voluntarily developed adaptation strategies to manage threatened water resources. | Public-Private Partnership (PPP) mechanism raised Ecological Infrastructure funding. The government launched policies to protect water resources and investment in water infrastructures. |
| Sheremet et al. 2018 | 2018 | Finland | Intervention | Empirical | Mitigate risks from invasive forest pests and diseases | The willingness of the general public to fund a PES scheme depended on benefits from a forest | The policy designers to encouraged spatial coordination in the uptake of PES-type contracts to deliver control measures on disease, risks and maximise social benefits |
| Riley et al. 2018 | 2018 | UK | Outcomes Interventions | Perspective, theoretical | Not defined | Not defined | To encourage more joined-up thinking by offering payments to farmers to form collective agreements for conservation. |
| Hardy et al. 2018 | 2018 | Australia | Policy review | Empirical | Protecting biodiversity on private land | Revolving funds were used by conservation organisations to buy, resell and permanently protect private land with important ecological values. | Conservation organisations used 'revolving funds' to acquire private land with high conservation value and then resell it to new owners, adding an in-perpetuity conservation covenant or easement. The agreement permanently restricts activities harmful to biodiversity. |
| Reinhardt et al. 2018 | 2018 | Vietnam | Need and Willingness | Empirical | Establishment of plantations, abstinence from logging a plot of mature plantation trees or refrain from cutting indigenous hardwood trees. | Willingness to engage in contracts was motivated by compensation | REDD+ (Reduced Emissions from Deforestation and forest Degradation) social safeguards promoted the improvement of local communities' livelihoods. |
| Arnott et al. 2019 | 2019 | England | Intervention | Empirical | Promote 'greening', 'sustainability' and 'ecosystem services' approaches to land management. | Environmental, economic and social benefits of result-oriented schemes outcomes drive willingness. Factors such as climate change, the behaviour of neighbouring farmers and the breeding, feeding, and migration patterns of mobile species all have the potential to influence willingness to participate. | Used action-based AES, as a delivery mechanism for ecosystem services |

Note: **The listed studies excluded sources who could not fill all the gaps. Those were included in the reference list to save the space. These studies are ordered by publication dates.**

**Appendix 5**: A table that shows relationships between concepts and willingness determinants for the second research data chapter.

| Relationship descriptor | Explanation |
|---|---|
|  | Is associated with |
|  | Contradicts |
|  | Is part of |
|  | Is a property of |
|  | Is a |

Based on: Dempster, M. (2003). Systematic review. In Miller, R. L., & Brewer, J. The A-Z of Social Research. London: SAGE. http://dx.doi.org/10.4135/9780857020024